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# JPRS Report



# Science & Technology

## CHINA: Energy



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# Science & Technology
## China: Energy

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## Major Investment Urged To Beef Up Energy Sector

*40130075a Hong Kong LIAOWANG [OUTLOOK WEEKLY] in Chinese No 10, 6 Mar 89 pp 9-10*

[Article by Lin Chen [2651 2525]: "China's Energy Resource Industry Awaits True 'Slanted Investments'"]

[Text] The Chinese economy has many problems and generates much discussion. Inflation has recently become a hot topic on the streets and in the alleys, and energy shortages are getting increased attention.

### I. Shortages of Electric Power, Coal, and Oil

A. The power shortage: In the past, mainland China "threw switches and restricted power" (shut off power and restricted supplies). At that time, however, we "threw the switch on a single line" but now we "throw the switch everywhere." Even hospitals are being affected. In the past, power shortages occurred only in coastal east China but now they "infect" all of China. Some northwestern and southwestern provinces which ship out energy resources are even unable to fend for themselves. Gansu historically has been a province which transmitted power to the rest of China but it began receiving power transmissions in 1988. An official in the Gansu Provincial Planning and Economics Commission warned not long ago at the National Energy Work Conference that Gansu cannot continue supporting the westward migration of high energy consuming industries. He called for construction of nuclear power plants in Gansu. The phenomenon of enterprises shutting down for 3 days and operating for 4 days is extremely common throughout China, and power supplies are even cut off regularly to some coal mines. One-third of China's industrial production capacity has been idled as a result. Shortages of power for agriculture are even more severe. There are stories of people sitting beside their motor-pumped wells through the night during busy seasons waiting for power which comes intermittently.

B. The coal shortage: Everyone says that Shanxi has plenty of coal and that the only problem is shipping it out. Rough estimates are that more than 40 million tons of coal is lying on the ground waiting to be shipped out. However, Shanxi Provincial vice governor Wu Junzhou [0702 0193 3166] warned everyone at the Energy Work Conference that Shanxi also has a coal shortage and the problem now is not that it cannot be shipped out, but instead that there are no coal sources. With the exception of some soft coal in southeast Shanxi which is unwanted because its heat value is too low, the so-called "40 million tons of coal lying on the ground" actually is coal spread on the floor at more than 6,000 coal mines which cannot be extracted! He is afraid that a "coal shortage" may appear during the first quarter of 1989.

Henan Provincial vice governor Liu Yuan [0491 3293] also complained of hardship. He predicts that, given the current situation, it is quite possible that Henan, a big coal exporter, will have no coal to export at the end of this century.

The coal shortage directly affects power generation. Director Zhou Xianggen [0719 4382 2704] of the East China Power Management Bureau told reporters that shutdowns in the East China Grid due to coal shortages in December 1988 averaged 2 million kW per day, and shutdowns of 1.288 million kW per day persist into the beginning of 1989. Baogang's own power plant also has shut down its boilers on occasion because of the coal shortage. In a news conference, Minister Huang Yicheng [7806 3015 6134] of the Ministry of Energy Resources revealed that the amount of coal supplied for power generation in China in 1988 was 8 million tons less than planned, equal to 3.5 percent of all coal used to generate power.

C. The oil shortage: China's petroleum industry expended a great deal of effort in 1988 just to increase petroleum output by 2.2 percent to 137 million tons, but it cannot meet demand in the refining and petrochemical industries. There is a particular shortage of fuel oil which has even greater effects. A mine at Yangquan in Shanxi reported 1.5 million tons of coal on hand which it would release when equipment was dispatched. One look showed that a lack of oil had forced over 20 bulldozers to "lie in their nests."

The oil shortage is affecting coal shipments, the coal shortage is affecting power generation, and the power shortage is affecting coal extraction. Huang Yicheng said that China is now experiencing its worst energy shortage in 20 years.

The energy shortage has severely restricted development of the national economy and the people's livelihood.

#### Actively Discuss Reasons for the Energy Shortage and Countermeasures

All areas in China are paying extremely close attention to the energy shortage and they are actively discussing reasons and countermeasures for it. As for the reasons, two theories are very representative. The first is inadequate coal shipping and that transportation inadequacies have caused coal shipments outside of plans to squeeze out coal shipments within plans. The second theory is that the economy is overheated.

Without a doubt, inadequate transportation is an important reason. To say that shipments outside of plans have squeezed out shipments within plans, however, we must divide it into three situations for additional analysis. The Datong Railway Bureau informed reporters that it is responsible for one-half of the tasks involved in shipping coal out of Shanxi, and that the amount of coal shipped within plans was 2 percent over the quota. Most of the

coal was used to generate electricity. However, it is very hard to say that all coal within plans was supplied to coal-using enterprises. This is the first situation: coal for use within plans may have flowed outside of the plans.

The second situation: coal used outside of plans is flowing into coal used within plans. Vice Minister Tu Yourui [1458 3945 3843] of the Ministry of Railways discussed this type of situation: the Dou He Power Plant in Tangshan Prefecture, Hubei is a large power plant which needs 1.7 million tons of coal yearly. The original plan was for Kailuan Mining Bureau's Jinggezhuang Mine located only 3.5 km away from the power plant to supply the coal. However, this mine supplied just 600,000 tons in 1988. The power plant had to buy the remaining 1.1 million tons from Shanxi, more than 500 km away, and transport it in as a shipment outside of plans.

The third situation is that coal used outside of plans has taken over transportation capacity. In 1988, Jiangsu stated that supplies of coal for power within plans would be reduced by 20 percent but at the same time 80 percent of the coal used outside of plans and transported by rail was shipped to Jiangsu. Jiangsu has many township and town enterprises which still are not "included in plans" and we must ask them if there aren't reasons for shipping coal outside of plans.

To go back one step, would compensating for the 8 million ton shortage of coal for generating power solve the problem? Chief engineer Lu Yanchang [7120 1693 2490] in the Ministry of Energy Resources provided some very telling data. In 1987, the total installed generating capacity in China reached 100 million kW, giving us the capacity to generate 500 billion kWh of electricity annually. The total installed capacity of power consuming equipment, however, reached 288 million kW during the same period, requiring 800 billion kWh of power, giving an enormous gap of 300 billion kWh. Moreover, an additional 8 million tons of coal would only generate an additional 13.5 billion kWh. A figure of 13.5 compared to 300 is totally inadequate!

Then there is the idea of the overheated economy. Data provided by the Ministry of Energy Resources shows that, under extremely difficult conditions in 1988, China exceed power output quotas by 9.3 percent, coal output quotas by 3.5 percent, and oil extraction quotas by 2.2 percent in achieving 2 percent growth in total energy output. When compared to the 17 percent increase in the gross value of industrial output and 11 percent increase in the gross value of agricultural output in 1988, however, a balance would be hard to achieve. Economic overheating is obvious.

Some knowledgeable people in China have pointed out that lowering the temperature of our overheated economy is essential to achieving a fundamental reversal in this passive situation. From the long-term perspective, however, it is even more important that we make a firm decision to increase investments in the energy industry, and the energy industry anxiously awaits truly "slanted investments."

**III. Serious Lags in Energy Investments**

When all the developed nations were in the initial stages of development, energy production developed in a leading manner. Professor (Seluo), director of the Sloane School of Management at MIT in the United States, told State Council member Zou Jiahua [6760 1367 5478] during a visit to China not long ago that an 8 to 9 percent rate of growth in electric power in China could only support a 6 to 7 percent rate of growth in the gross value of industrial and agricultural output.

Information from the Ministry of Energy Resources indicates that during the 10-plus year period from 1953 to 1965, installed generating capacity and power output grew at average yearly rates of 17 percent and 18.7 percent, respectively, and the rate of growth in China's electric power industry exceeded that of the gross value of industrial and agricultural output. Although the electric power industry sustained its leading position over the next 10 years, a tendency to "live off past gains" started revealing itself. Beginning in 1980, China's economy grew rapidly and universal shortages of energy resources began appearing.

Between 1980 and 1985, the gross value of industrial and agricultural output in China grew by 68 percent, whereas primary energy resources (coal, oil, natural gas, and other unconverted energy resources) grew by only 34 percent and power output by 37 percent. The average rate of growth in the gross value of industrial and agricultural output in China from 1986 to 1987 was more than 14 percent, but primary energy resources grew by about 3 percent yearly and electric power output by 10 percent annually. A comprehensive comparison shows that the gap between energy resource development and economic development in China continued to widen after 1986 and the rate of growth in energy resource production itself slowed substantially. This was directly related to insufficient inputs.

If we agree that the gross value of industrial and agricultural output has grown too quickly and that electric power cannot keep up, the situation in the energy industry is that electric power has grown quickly while coal has fallen behind.

The momentum of growth in coal production in China was sustained in 1986 and 1987, with output rising by 21.7 million tons in 1986 and 34 million tons in 1987. The increase in output was greatest at 42 million tons in 1988 when total output reached 960 million tons. The relevant authorities feel, however, that sustaining this

sort of production level actually would depend on "living off past gains." If it continued for any period of time this rate of growth would be impossible to sustain into the future.

Manager Yu Hong'en [0060 3163 1869] of the State Unified Distribution Coal Corporation said that most old mines reached peak output prior to 1980 and that the intensity of extraction in eastern coal mines was excessive, having already exceeded the design production capacity by 40 percent, with an even faster rate at the oldest ones. Projections are that 43 million tons of mine production capacity will [be] abandoned by the year 2000, with output at the oldest ones falling by 30 million tons. Moreover, extraction conditions are becoming increasingly complex and depths are dropping about 10 m/year. Most complete sets of coal extraction equipment have been operating for over a decade and urgently require replacement. These factors have greatly increased the cost of coal extraction and the coal industry has been operating at a loss on an industry-wide basis. Shanxi, Shaanxi, and other big coal producing provinces have stated that some mines are using expenditures for simple reproduction to pay wages. Coal production is in dire straits in an extremely difficult situation.

Even greater problems await us in the future. The state planned to invest 19.5 billion yuan in the coal industry from 1986 to 1988, but actually invested only 17.8 billion yuan. Coal construction plans for 1989 and 1990 will require 19.8 billion yuan in investments, but the State Planning Commission can only provide 12.4 billion yuan. The direct result of reduced investments is that capacity at new mines opened since 1985 was only 49.92 million tons, just 37 percent of planned new capacity. These data indicate a possibility that no new unified distribution coal mines will go into operation in the year 2000.

After reform and opening up, China's investment system was reformed and there was a substantial increase in avenues for investment and a "three-three system" configuration basically took shape. Investments in the budget controlled by the State Planning Commission account for one-third, roughly 100 to 120 billion yuan each year. Investments outside the budget controlled by localities and by enterprises each account for one-third, or about 100 billion yuan each year. Thus, while energy investments comprised 20 percent when the state arranged the Seventh 5-Year Plan, actual investments in energy resources declined substantially as a portion of total fixed assets in society.

Thus, this valuable 20 percent could not be completely guaranteed. In the Sixth 5-Year Plan, inputs in the energy industry accounted for 21 percent of all planned inputs, but only 18 percent was actually implemented. The plan was for 20 percent during the Seventh 5-Year Plan but estimates are that only 18 percent can be completed.

In the overall balance, capital invested in China's energy industry now accounts for just 11 percent of total investments in social fixed assets. The Soviet Union, however, is spending 30 percent of its total investments as capital for energy construction each year. The World Bank recently compiled statistics on investments in electric power in more than 40 developing and developed nations during their development periods. They confirm that investments in electric power must equal 2 percent of GNP before it can meet the needs of economic development. All of Asia's "four small tigers" [Hong Kong, Taiwan, South Korea, and Singapore] have attained this level. China, however, reached only about 1 percent during the Sixth 5-Year Plan and no changes have been made in the past few years.

Increasing this percentage would imply a need to double investments in electric power.

**IV. Achieving "Slanted Investments"**

We must find a way to tip the balance in inputs toward energy resources. Some major ideas are enlightening:

1. "Slanting" depends on state inputs, but the first thing is policy inputs. We now have policies for raising capital for electric power construction, and the results are not bad, so could they be used for coal and oil?

2. The scarcity of things makes them valuable, but in China energy resources are scarce but not expensive. This is the main reason that capital has been hard to raise for energy resources. The principle of capital circulation is that a profit can be earned. The price of energy is too low, however, and the entire petroleum and coal industries are operating at a loss, while profits from electric power are miniscule. This is quite similar to a "three-edged knife": it "hurts" initiative to put capital into the energy industry, it "hurts" initiative for self-development in the energy industry, and it "hurts" initiative in all areas and all industries to reduce waste and raise energy resource utilization rates. Moreover, the only things receiving encouragement are the related processing industries since they can earn high profits from the cheap energy. Thus, development of the energy resource industry is sacrificed for "high benefits" in processing industries, which eventually can damage the health and growth of the national economy.

3. Some people feel that raising energy prices now would cause more inflation, so they propose going slowly. Those in the know, however, have pointed out that we must decide now to readjust state investment plans and shift toward energy resources on a major scale, meaning that we should not hesitate to destroy the existing overall equilibrium. The reason is that the current equilibrium is actually based on a serious loss of equilibrium in the industrial structure. Plans are designed to serve development, but we cannot demand in turn that development be adapted to plans.

After visiting China, a Japanese economist said that China's present energy resource investment situation basically cannot be considered "slanted" when compared to the extent of the energy shortage. Japan also implemented a "slanted policy" to deal with its post-war energy shortage, even to the extent of slanting until some industries were squeezed quite hard and forced to close. This should enlighten us in China.

## Energy Production Up in First Quarter'89

*40100042a Beijing CEI Database in English 5 Apr 89*

[Text] Beijing (CEI)—China produced 210 million tons of raw coal in the first 3 months of this year, 22 percent of the state target of this year and an increase of 5.32 percent compared with the same period last year.

Meanwhile, China also produced 240 million BBL of crude oil, 3.5 billion cubic meters of natural gas and 240 billion kWh of electricity, all of which are slight increases compared with the same period last year.

According to an official from the Ministry of Energy Resources, many coal mines in Shanxi and Shandong provinces, and Northeast China have overfulfilled their production targets.

But, he said, coal production has been seriously affected due to shortages of mine timber, steel, cement, and electricity.

## February Energy Figures Released

*40100043a Beijing CEI Database in English 10 Apr 89*

[Text] Beijing (CEI)—Following is a table of China's total output of primary energy production in February 1989, released by CSICSC [China Statistics Information Consultancy Service Center]:

| Item | Unit | 1-2/89 | 2/89 | percentage over 1-2/1989 |
|---|---|---|---|---|
| total output (10,000 tons of standard coal) | | 13470.0 | 6086.0 | 101.50 |
| a. raw coal | 10,000 tons | 13281.0 | 5847.0 | 102.20 |
| including: output under unified central planning | 10,000 tons | 7066.0 | 3224.0 | 101.50 |
| b. crude oil | 10,000 tons | 2187.4 | 1042.8 | -101.90 |
| c. natural gas | 100 million cubic meters | 24.41 | 11.78 | 101.80 |
| d. hydropower | 100 million kWh | 132.50 | 65.30 | 109.50 |

## Energy Shortage Hobbling Shanghai's Industry

*40100039a Shanghai SHANGHAI FOCUS in English 13 Mar 89 p 1*

[Article by Chen Weihua: "Energy Lack Slows City"]

[Text] The shortage of coal is seriously endangering industry in the city.

The power supply to many factories is stopped regularly and a queue has been formed to buy coal.

Many factories are running only four or five days a week because of the power shortage.

Daily power generating capacity of the East China's power network has been reduced 10 million kilowatt hours compared with last year.

There is a gap of about two million tons in coal and 400,000 tons in oil based on this year's city plan.

Local industry consumes 27 million tons of coal each year. Last year's energy consumption totalled more than 30 million tons of standard coal.

Energy consumption in the city increases at an average of about 980,000 tons of standard coal a year. Experts said that this is due to the rapid development of some high energy consuming industries, such as metallurgical and petrochemical.

The start of the production of the first phase of the Baoshan Iron and Steel Complex in 1985 and the second phase of the Jinshan Petrolchemical Plant in 1986 has meant the consumption of an additional four million tons of standard coal a year.

Another 250,000 tons of standard coal will be consumed a year when the furnace in the Shanghai No 1 Iron and Steel Plant starts production soon.

An expert called for an adjustment in industrial structure to solve the problem of energy shortage. He said an increase in the proportion of light industry would mean a saving in energy for the city.

He added that Shanghai should take advantage of such industries as textile, handicraft, electronics and light industries, which consume less energy.

The expert said that Shanghai should further develop its service-related industries, which can achieve the same production value with less energy consumption. A one per cent increase in the service industry set against the city's total gross national product would mean an energy drop of 220,000 tons of standard coal.

The expert also called for the development of a more centralized heating system to change from the present situation under which all enterprises burned their own heating boilers.

He said the speed of the development of the power industry should exceed that of the national economy.

About 15 per cent of local productivity has become idle because of the energy shortage. Local observers said that because of the vital status of Shanghai in the nation's economy, a way should be worked out to assuage the acute energy shortage.

Shanghai's output value accounts for 10 per cent of the nation's total. Its revenue accounts for one-sixth, foreign trade one-sixth and the harbour loading and unloading capacity one-third. (CD News)

## Focus on MHD, Fusion Technologies

*40100042b Beijing CEI Database in English 7 Apr 89*

[Text] Beijing (CEI)—China has listed the coal-fired MHD power generation technology and nuclear reactor technology as the development focal points in its energy technology research and development plan.

According to the plan, coal-fired MHD power generation technology will be developed to improve thermal conversion efficiently, conserve coal resources, fully utilize medium-grade and high-sulfur coals which are abundant in China, and to reduce the pollution and transportation associated with traditional power generation through coal combustion.

On the nuclear reactor technology, in view of the development of nuclear energy in the 21st century, a choice will be made to develop a safe, economically viable and highly fuel efficient type of reactor among fast breeder reactor, high temperature gas cool reactor and fusion-fission hybrid reactor that uses existing fusion technology.

## Power Shortage Still Critical in Guangdong

*40130078a Guangzhou NANFANG RIBAO in Chinese 2 Feb 89 p 1*

[Article by reporter Wang Dekuan [3769 1795 1401]: "Major Development of Electric Power Construction in Guangdong During 1989, Power Shortages Persist, Construction of Second Nuclear Power Plant Now Being Studied"]

[Text] Guangdong Provincial Electric Power Bureau director Chen Gang [7115 1511] said during a visit by reporters on 1 Feb 89 that electric power will develop substantially in Guangdong in 1989, but the power shortage will continue.

Chen Gang said that 550,000 kW in large and medium sized generators will go into operation during 1989, with 10.5 percent real growth in power output over 1988. Because Guangdong's economy has grown rather quickly in the past few years, however, power shortages continue. The water level at hydropower stations is low at the present time, which has affected additional hydropower generation. There are coal shortages throughout China and most of the coal used in Guangdong is shipped in from other provinces, so coal-fired power output may be affected.

Guangdong's energy resource situation requires that the province achieve two shifts during the period from 1991 to 1995. The first is a shift from a focus on thermal power construction to an energy structure dominated by hydropower, nuclear power, power generated from oil shale, and so on. Preliminary research on Guangdong's second nuclear power plant and an oil shale power plant is now underway. The second thing is to shift from relying simply on Guangdong itself to full utilization of the province's resources along with active participation in developing electric power in southwest and Guangxi, establishing a framework to transmit power from west to east China, and using multiple channels to solve Guangdong's electric power problems.

## Huang He Basin Being Developed As Huge Energy Base

*40130075b Hong Kong LIAOWANG [OUTLOOK WEEKLY] in Chinese No 10, 6 Mar 89 pp 18-19*

[Article by Yang Yinglan [2799 5391 5695]: "Huang He Basin Being Developed To Build an Energy Resource Base Area"]

[Text] The Huang He Basin is becoming one focal point among China's three big conventional energy resource base areas, and everyone is calling it an "energy basin." Energy resource industries are now being deployed in a coordinated fashion up and down the big river, with a hydropower base area in the upper reaches, a coal base area in the middle reaches, and a petroleum base area in the lower reaches. According to incomplete statistics, these base areas provided 32 percent of China's coal, 29 percent of its petroleum, and 10 percent of its hydropower.

### I. Abundant Resources Await Development

In the past few years, as the Huang He has come under control, mineral resources lying dormant underground are gradually being developed.

Survey figures contained in a report to the Huang He Control and Development Planning Conference May 1988 stated that mineral reserves in the Huang He Basin comprised the following proportions of total national reserves: coal 46.14 percent, petroleum 25.6 percent, rare earths 96.4 percent, and molybdenum 44.4 percent. It also contains aluminum, lead, copper, tungsten, and other nonferrous metals as well as precious metals, and others. In the area of energy resources, coal reserves are located mainly in the four provinces and autonomous regions of Ningxia, Inner Mongolia, Shanxi, and Shaanxi in the upper and middle reaches, which account for 95.1 percent of total reserves in the basin. Most petroleum reserves are in Henan and Shandong Provinces in the middle and lower reaches of Huang He. The total developable installed generating capacity from hydropower resources exceeds 28 million kW, located mainly in the upper reaches of Huang He in the section between Longyang Gorge and Qingtong Gorge.

Senior engineer Liu Shanjian [0491 0810 1696] of the State Planning Commission Territorial Bureau said that Huang He Basin energy development and construction holds an important status in overall territorial development deployments. Based on the current situation in state construction and development requirements, China has demarcated over 10 key comprehensive development regions with the coast and Chang Jiang as the primary axes, and a line from Gansu to Qinghai, a line from Beijing to Guangzhou, and so on as secondary axes. The Huang He Basin is third among them, and includes the Jiaodong region at the mouth of the Huang He, an energy resource base area centered on Shanxi, and a hydropower construction base area in the upper reaches of the Huang He centered on Lanzhou.

### II. The Three Main Pillars of Hydropower, Petroleum, and Coal

Energy resource development and construction in the Huang He Basin began with hydropower. Following the demands of economic construction and advances in science and technology, coal and petroleum development also has proceeded quickly in the middle and lower reaches, and several projects were included among key state construction projects in the Sixth and Seventh 5-Year Plans.

In the 1950's, China began making hydropower resource utilization on the upper reaches of the Huang He a development focus and successfully carried out hydropower cascade development and construction on the trunk. The four hydropower stations at Liujia Gorge, Qingtong Gorge, Yanguo Gorge, and Bapan Gorge were built and put into operation prior to the 1970's. They have a total installed generating capacity of 1.964 million kW. The amount of power generated at the Liujia Gorge hydropower station surpassed the total amount of power generated in China in 1949. Entering the 1980's, China built the Longyang Gorge hydropower station, which became known as "the first dam on the 10,000-li Huang He," and began construction of the Lijia Gorge hydropower station. A preliminary scale now has been attained at the Longyang Gorge hydropower station. The reservoir capacity is 27 billion $m^3$ and it already holds 6.1 billion $m^3$ of water. When the three generator units begin operation, plans are for 6 billion kWh of power to be generated annually. Formal construction began at the Lijia Gorge hydropower station in April 1988. The installed generating capacity at this power station will be 2 million kW, second only to the Gezhouba hydropower station on the Chang Jiang. These two big hydropower stations show that hydropower development on the trunk of the Huang He has entered a new stage.

Deputy chief engineer Wan Jingwen [8001 2529 2429] in the Northwest Survey and Design Academy said that continued development of hydropower resources on the upper reaches of the Huang He is now a focus of state electric power industry construction. China is now considering compensatory readjustments extending beyond the river basin and employing the concept of large power grids for rational hydropower resource development and utilization.

He revealed that, with the exception of the already-completed Daxia hydropower station, cascade development projects on the upper reaches of the Huang He will involve building seven or eight more hydropower stations, including three large and medium sized backbone projects at Laxiwa, Gongbo Gorge, and Xiaoguanyin (or Daliushu) which will have 75 percent of the installed generating capacity of hydropower stations awaiting

construction. Nevertheless, further discussion is needed concerning the development sequence for projects awaiting construction. China believes, however, that it will build 14 or 15 hydropower stations on the upper reaches of the Huang He within the next 10 to 20 years.

The two large Shengli and Zhongyuan petroleum base areas in the lower reaches of the Huang He developed along with advances in S&T in China. On the basis of demarcating geodesic structures, Chinese geologists carried out theoretical discussions and surveys of the petroliferous prospects of the North China Plain, which led to exploration and development of the Shengli oilfield. The first well in this oilfield was drilled in 1964. Since the beginning of the 1980's, China has made new breakthroughs in geological theory which have brought rapid progress in exploration and development of the Shengli oilfield. More than 50 oil pools have been discovered and extraction has begun at 40 oil pools, making it China's second largest oilfield after Daqing. In 1983, China's State Council decided to accelerate exploration and development to build the Zhongyuan oilfield which runs through both Henan and shandong provinces. Some experts feel that a natural gas production base area can be built here in the east China region. My understanding is that this oilfield is importing technical equipment from the United States, France, the Federal Republic of Germany, and other countries, and foreign survey well teams and drilling teams have been hired to work at the oilfield. The oilfield has invited foreign specialists to give lectures and train technical personnel. Over the past few years, this oilfield has spent over $450 million in foreign investments to import more than 4,800 pieces of technical equipment. Annual crude oil output in 1988 was 7.2 million tons, fourth largest among China's oilfields.

The coal base area in the middle reaches of the Huang He includes the Jungar, Shenfu Dongsheng, Shanxi, West Henan, and other coalfields.

In the past few years, Shanxi, a major coal producer, has become north China's main coal production base area with yearly output in excess of 200 million tons. In addition, there has been simultaneous construction of several new power plants and stations which have increased the capacity for local conversion of raw coal.

In the past 2 or 3 years, large-scale construction of several coalfields began in Shaanxi and Inner Mongolia along the middle reaches of the Huang He. There are two main coalfields. One is the Shenfu Dongsheng coalfield which runs through Shaanxi and Inner Mongolia, and the other is the Jungar open pit mine on the Ordos Plain in southern Inner Mongolia. Preliminary proven reserves at the Shenfu Dongsheng coalfield, one of the world's seven biggest high quality coalfields, exceeds 230 billion tons. According to state plans, new extraction of high quality coal at this coalfield will be supplied mainly for large cities and export. The scale of mines in this coalfield will reach 60 million tons by the end of this century and it will become China's new coal capital.

Given the coalfield's location in a distant frontier region of the interior and the inconvenient communications, China has taken steps to coordinate coalfield development and railway construction, and efforts are underway to rebuild the two 470 km-long dedicated coal transport railways running north from Shenmu to Baotou City in Guzhong Township, Inner Mongolia, and east form Shenmu to Shuoxian in Shanxi. Preparations also are underway to build several large and medium sized pitmouth power plants.

Many experts feel that large scale construction and extraction at these large coalfields is indicative of China's strategic shift in the focus of coal development from east to west. They predict that by the 2030's, the coal base area in the middle reaches of the Huang He will provide more than 600 million tons of China's coal needs.

### III. A Major Effort To Shift Energy Consuming Industries to the West

Rapid growth in the Huang He Basin energy resource base area is playing an extremely important role in building China's energy resource industry and national economy.

Shengli and Zhongyuan oilfields in the lower reaches of the Huang He have become important pillars of China's petroleum industry. These two oilfields produce 40 million tons of crude oil and 2.5 billion $m^3$ of natural gas annually. Yearly crude oil output at the Shengli oilfield has reached 33 million tons, equal to 24 percent of total crude oil output in China. It has turned over five times as much in taxes and profits as was invested in it and exports of some of its crude oil have earned $7.5 billion in foreign exchange.

The crude oil and natural gas provided by the Shengli and Zhongyuan oilfields have given rise to several modernized large scale petrochemical industries in the lower reaches of the Huang He. They include completion of the second stage project by the Jilu Petrochemical Company in Zibo City, Shandong which will produce 300,000 tons of ethylene annually and become one of China's biggest chemical industry and plastics base areas; completion of an oil refinery in ancient Luoyang City which will process 5 million tons of crude oil annually; completion and startup in 1989 of a large chemical fertilizer plant in Puyang City which will produce 300,000 tons of synthetic ammonia each year; and starting construction at another ethylene project which will produce 140,000 tons of ethylene annually. The startup of these petrochemical projects will be of enormous assistance to industrial and agricultural construction in Henan and Shandong provinces, which historically have suffered destructive flooding and have large populations.

The Shanxi coal base area holds first place in China in both the amount of coal it ships out and the amount of power it transmits out. It supplied 3.5 billion kWh of electricity to Beijing and Tianjin Municipalities, Tangshan City, and other areas in 1987, up by more than 60 percent over 1985. The coal it shipped out amounted to more than 80 percent of all commodity coal in China.

Hydropower stations on the upper reaches of the Huang He now produce 50 percent of the power generated in the Northwest China Grid. Several high energy consuming industries centered on the nonferrous metals smelting, petrochemical, and saline chemical industries in the upper reaches of the Huang He have attained a preliminary scale. Statistics show that Gansu, Qinghai, Ningxia, Shaanxi, and other provinces and autonomous regions have built more than 20 enterprises to process aluminum, nickel, copper, lead, and other nonferrous metals with a cumulative value of output of 500 million yuan that have become an important nonferrous metals smelting base area in China. After the three large hydropower stations on the upper part of the Huang He trunk at Liujia Gorge, Yanguo Gorge, and Bapan Gorge were completed, China built more than 30 nonferrous metals enterprises and mines here for five large high energy consuming production systems for electrolytic copper, electrolytic nickel, electrolytic aluminum, lead, and zinc that now hold first place in China in yearly output.

Wan Jingwen said that most of China's high energy consuming enterprises were concentrated in north and northeast China. Following the development of Huang He hydropower in recent years, the center of the high energy consuming industries has shifted westward to the various provinces and autonomous regions of the vast northwest. Completion of the large power stations in the future will speed up this westward shift. He said that expansion and new construction of several electrolytic aluminum plants in Shaanxi, Gansu, Ningxia, and Qinghai provinces and autonomous regions is being synchronized with construction of the Longyang Gorge hydropower station. Qinghai Province is now building China's largest electrolytic aluminum plant with a design output scale of 200,000 tons of aluminum nails each year. The annual power load will be 400,000 kW. Five years from now, output of various nonferrous metals in northwest China will be double the current figure.

New cities centered on the energy resource industry are developing and growing in the Huang He Basin. They include Dongying and Puyang Cities, centered on the petrochemical industry, Dongsheng city, centered on coal, the nickel capital "Jinchuan," the "copper capital" Baiyin, and so on. Dongying City, on the Huang He delta, is a petroleum city which took shape following development of the Shengli oilfield. The State Council formally approved its establishment in 1983 and it now has a population of 1 million. Dongying city vice mayor Zhang Qingli [1728 1987 7812] said that according to development plans, accelerated development of the petrochemical industry will proceed concurrently with development of beaches and saline-alkaline lowlands and comprehensive development of agricultural resources to turn the Huang He delta into another treasurehouse equal to the Pearl River and Chang Jiang deltas.

## Trends in Modern Hydropower Equipment Development Summarized

*40130043 Shanghai DONGLI GONGCHENG [POWER ENGINEERING] in Chinese No 5, 15 Oct 88 pp 1-7*

[Article by Bian Shanqing [6708 0810 1987] of the China Electrical Engineering Equipment Corporation: "Modern Hydropower Equipment Development Trends"]

[Excerpts] [Passage omitted]

### VI. Development of China's Hydropower Equipment Manufacturing Industry

China's hydropower manufacturing industry has come into being and grown quickly since the nation was founded, and it has formed a rather complete scientific research, design, and manufacturing system. Statistics show that China now has 67 fixed site hydropower equipment plants under the Machinery Commission employing almost 100,000 workers and over 10,000 engineering and technical personnel. Key plants include the Harbin Electric Machinery Plant, Dongfang Electric Machinery Plant, Tianjian Power Generation Equipment Plant, Hangzhou Power Generation Equipment Plant, Chongqing Water Turbine Plant, Kunming Electric Machinery Plant, Nanping Electric Machinery Plant, Shaoguan Water Turbine Plant, Jincheng Jiang Hydropower Equipment Plant, Lingling Hydropower Equipment Plant, Jinhua Water Turbine Plant, Linhai Electric Machinery Plant, Shaoyang Water Turbine Plant, and others. By the end of 1985, China had designed and manufactured 22,500 MW in large and medium-scale hydropower equipment capacity, about 85 percent of our total installed generating capacity. China has exported more than 200 medium and small-scale hydropower generators over the past few years, the largest having a unit capacity of 31,000 kW, to the United States, Peru, the Philippines, Thailand, Sri Lanka, Turkey, and other countries.

Before liberation, China's industrial foundation was extremely backward, and we had practically no hydropower equipment manufacturing industry of our own. We had only 360 MW of installed hydropower generators, all of it equipment imported from abroad. After liberation, China built and expanded several hydropower equipment manufacturing enterprises. We built the Harbin Large Generator Research Institute, Tianjian Electric Drive Design and Research Institute, and other scientific research base areas to be responsible for hydropower equipment technical development and

new product design in China. In the 30-plus years since China developed its first 800 kW hydropower generator in 1951, we have produced mixed-flow, rotary blade, impulse, and other hydropower generators of various models and capacities. They include mixed-flow generators with a unit generating capacity of 300 MW at the Liujiaxia Power Station and the world's largest 170 MW axial flow rotary blade generators supplied to the Gezhouba Power Station indicating new levels in China's hydropower equipment manufacturing industry. China also designed and manufactured diagonal flow reversible water lifting energy storage generators, tidal bidirectional bulb flow-type and other new types of generators, and they went into operation at Beijing's Miyuan Hydropower Station and Zhejiang's Jiangxia Hydropower Station in 1973 and 1980, respectively, with rather good economic results.

[Passage omitted] One can see that China's hydropower manufacturing industry has developed extremely quickly. By the end of the 1950's, we had successfully manufactured 72,500 kW mixed-flow hydropower generators with water turbines 4.1 m in diameter. In the 1960's we developed 225 MW mixed-flow generators for the Liujiaxia Hydropower Station with turbines 5.5 m in diameter. We had already come near to world levels at that time in terms of single unit capacity. From the 1970's to 1980's, we developed new diagonal flow, tubular flow, water-lifting energy storage and other hydropower generators and we began exporting complete sets of hydropower equipment to foreign countries. Production of hydropower equipment in China basically meets the needs of hydropower construction, and it has made a substantial contribution to the development of China's national economy.

Following the 3d Plenum of the 11th CPC Central Committee, under the guidance of the principle of opening up to the outside world, China's hydropower equipment manufacturing industry has undertaken broad-ranging technical circulation and cooperation with famous manufacturing enterprises in foreign countries and actively imported advanced technologies. An example is the recent cooperation between the Harbin Electric Machinery Plant and Norway's KB Company and Siemens in the Federal Republic of Germany for cooperative production of 150 MW high-head, mixed-flow water turbine generators for the Lubuge Hydropower Station in China's Yunnan Province. This was the first cooperative project between China and foreign countries in the area of large-scale hydropower equipment. Practice has proven that using the cooperative production pattern to import technologies and equipment, particularly importing large-scale complete sets of equipment, can provide better results than other types of technical cooperation. China now is implementing planning, design, and construction work for large and medium-scale hydropower stations with 40,000 MW in installed generating capacity, and we are developing even higher capacity large scale hydropower generating units for Yantan, Wuqiangxi, Longtan, Ertan, the Three Gorges, and others. Development plans indicate that the total installed hydropower generating capacity in China will reach 80,000 MW in the year 2000. Thus, the tasks now facing China's hydropower equipment manufacturing industry are extremely arduous ones and we must earnestly summarize experiences based on existing foundations to actively import advanced technologies from abroad, improve manufacturing levels for China's hydropower equipment, and provide the cause of hydropower construction in China with more and better hydropower equipment.

## Gezhouba Installs Final Transformer

*40100041a Beijing XINHUA in English 1158 GMT 4 Mar 89*

[Summary] Beijing, 4 Mar (XINHUA)—The last transformer for the Gezhouba power station was installed on 1 March, which means that the station will soon transmit electricity to east China, says today's PEOPLE'S DAILY. The construction of the dam started in 1974. The power station, with a designed capacity of 2.715 million kW, one-fifth of the total electricity in the central China network, will do much to alleviate the power shortage in central China. The direct-current and alternating-current station, which has a 600,000-kW transmission capacity, has a higher voltage and greater capacity than any other in the country. The paper says it has seven transformers. All the equipment has been imported.

## Agreement Signed on Joint Venture Guangdong Station

*40130070a Guangzhou NANFANG RIBAO in Chinese 15 Jan 89 p 1*

[Text] Yesterday evening, at a signing ceremony held in Guangzhou and hosted by Vice Governor Kuang Ji, the Guangzhou Pumped-Storage Power Station Joint Venture Company signed an equipment introduction agreement with the Alsthom Company of France and a technology assistance agreement with the Electric Power Company of France.

The new pumped-storage power station in Guangzhou's Conghua County which has been approved by the State Scientific and Technological Commission and financed jointly by Guangdong Province and the State Energy Investment Company along with the Nuclear Power Investment Company of Guangdong Ltd. will improve Guangdong's supply of electric power. This power station in Guangzhou of 1,200 Megawatts total installed capacity will be China's first high water head, large capacity pumped-storage power station. The cost is 140 million yuan. Of this amount, 20 million U.S. dollars will be in the form of a loan from the Government of France for the importation of four reversible water-turbine generating units, auxiliary electromechanical

equipment and materials. It is estimated that the first unit will begin generation of electricity in late 1992 and all construction will be completed in 1994.

## Nantong Plant Adds 350-MW Unit To Grid

*40130070c Shanghai WEN HUI BAO in Chinese 11 Jan 89 p 2*

[Text] This morning at 2 am, a 350-MW generating unit at Huaneng's Nantong power plant began generating electric power for the grid.

The completion and entry into production of this generating unit has doubled the original 340 MW installed generating capacity of Nantong City.

Huaneng's Nantong power plant is the first Chinese-foreign jointly financed modern new power plant in Jiangsu to use both local and foreign capital. It is also the power plant with the largest capacity per unit in Jiangsu. Both 350MW units and all associated equipment included in the first stage of the project were imported from abroad and are of a technological sophistication representative of the advanced international level of the 80's.

Work was begun on the first generating unit, which has just joined the grid, in September 1986 and required a total period of 27 months. This is 2.5 months less than required for introduction of similar domestic generating units. Completion of the first stage of construction of Huaneng's Nantong power plant has great significance for the investment environment of Nantong City and for the alleviation of East China's tense power supply problem.

## Coal Utilization in China, Current Status and Forecast

*40130034 Beijing SHIJIE MEITAN JISHU [WORLD COAL TECHNOLOGY] in Chinese No 10, Oct 88 pp 1-4*

[Article by Li Shilun [2621 1597 0178], director of operations of the China Chemical Engineering Society and senior engineer of the Coal Chemistry Institute, Coal Science Academy: "The Current Situation and Prospects of Coal Utilization in China"; checked by Liu Pinshuang [0491 0756 7175]]

[Text] China has abundant coal resources with a full complement of varieties and high output. Coal output in 1987 was 925 million tons. Coal accounts for 76 percent of China's total energy resource consumption. In 1986, 75 percent of all coal consumed was coal used in industrial production and fuel coal for railroad locomotives. The electric power industry burned nearly 200 million tons of coal, industrial boilers consumed about 200 million tons of coal, and railroad locomotives burned about 25 million tons. Coal is an important raw material in the metallurgical and chemical industries. Machine coke production was 40 million tons in 1986. The chemical industry also consumes large amounts of coal, including about 40 million tons yearly in the chemical fertilizer industry. Most medium and small synthetic ammonia plants use coal as a raw material in synthetic ammonia production. Coal also is the primary household fuel in cities. Yearly urban and rural civilian coal consumption has reached 200 million tons. To reduce the serious pollution created by direct burning of coal, shaped coal is being extended and utilized, and the development of urban coal gas is being accelerated. Some 146 of China's 350-odd cities have established urban coal gas facilities and more than 30 million people now use coal gas fuel.

China has actively developed comprehensive utilization of coal since the nation was founded. In the Sixth 5-Year Plan, coal conversion and comprehensive utilization became a major technical policy for energy conservation and pollution prevention. This in turn brought expanded coal utilization activities and improved technical levels.

### I. The Development Situation for Coal Utilization Technologies

#### A. Combustion

To increase the heat energy utilization rate in coal and reduce environmental pollution, coal consumption by China's urban residents is shifting from burning loose coal to shaped coal. Shaped coal output in China reached 23 million tons in 1987. There is a 20 to 30 percent coal savings when shaped coal is burned compared to burning loose coal, and the thermal efficiency can be nearly doubled when advanced stoves are used.

China also has developed shaped coal especially for use in industrial boilers and steam locomotives, and aviation shaped coal used for winter temperature maintenance of aircraft engines which is being used in production. This invention received a Brussels Eureka Award. Burning this shaped coal involves simple operations, is safe and reliable, and does not pollute the environment. It is suitable for use not only to keep planes warm but also can be used for temperature maintenance of automobiles, and has been quite welcomed by users.

Rather good progress has been made in the combustion of coal-water slurry. Slurry-making plants have been established with yearly capacities of 50,000 tons at Fushun and 30,000 tons at Zaozhuang. Slurry from these two plants is undergoing trial combustion in a 20 ton-/hour industrial boiler, with rather good results. The average coal combustion efficiency is 95.2 percent and the average thermal efficiency of the boilers is 79.5 percent.

Although China has abundant coal resources, they are very unevenly distributed. Coal reserves are limited in southern provinces like Zhejiang, Funian, and others, but they have abundant bone coal. Although bone coal is a low heat value fuel, they should develop and utilize it to reduce their local energy shortages. Moreover, China's many coal mines produce large amounts of coal gangue each year. Thus, comprehensive utilization of low heat value fuels has become an important topic for research and solutions.

China has successfully developed fluidized-bed boilers capable of burning low heat value fuels with steam outputs of 4, 6, 20, 35, and 130 tons/hour. China now has more than 2,000 fluidized-bed boilers with a total steam output of 10,000 tons/hour. Some 13 coal gangue power plants with an installed generating capacity of 140 MW have been completed. The Jixi Coal Gangue Power Plant installed two 130 ton/hour fluidized-bed boilers fitted with 50 MW generators which have operated stably for a long period. China now has the conditions to design new types of 130 tons/hour fluidized-bed boilers.

Combustion in fluidized-bed boilers produces large amounts of slag with a low carbon content and rather good activation suitable for making clinker-less cement. A total of 36 cement plants which utilize slag from fluidized-bed boilers have been built with a total production capacity of 1.6 million tons. Research has been successful on using coal gangue to produce ceramic particles and aerocrete. The variety of brick products has expanded from just common bricks to surface bricks, hollow-core bricks, glazed bricks, and so on. Coal gangue-burning brickmaking plants now can be found throughout China. The coal system alone has 188 gangue brick plants which produce 1.6 billion pieces annually. Slag with a rather high dialuminum trioxide content is being used to extract crystallized aluminum oxide and solid polymer aluminum, and it has been in production for several years.

China also has made good progress in developing new technologies like cycled fluidized-bed and pressurized fluidized-bed combustion.

**B. Coal coking**

China is fourth in the world in coke output. We have more than 50 types of industrially-produced coking chemistry products. The coking industry has developed rather quickly since the nation was founded. We now can design and build coke ovens with carbonization chambers 6 m tall and a volume of 38.5 $m^3$, and we have the capacity to design 8 m tall carbonization chambers.

Many medium and small coke ovens also are operating which provide coke for blast ovens and the chemical industry.

To deal with the gas coal in China's coking coal and our considerable softly bonded coal resources, research was begun in the 1950's to expand coal used for coking, and a rather high level has now been attained. The proportion of weakly bonded coal in the mixture has surpassed 50 percent, saving large amounts of strongly bonded coking coal and changing the tradition of requiring a coal mixture for coking which contained the four "gas, fat, coking, and lean" coal types. Tamping coking techniques are obviously superior for expanding coking coal resources. China has built six tamping coke ovens and accumulated rich production experience.

Evaluation methods and $V^v$-G charts based on the characteristics of China's coking coal resources have been proposed for coal used for coking and they have played guiding roles in the coal mixture used in coking in certain coking plants. To provide the coal needed for the Baoshan Iron and Steel Company, China's largest iron and steel base area, rational coal mixing programs which studied eight coal varieties including Yanzhou gas coal and others have been used to produce coking coal suitable for use in modernized large blast ovens.

In addition, two-stage lignite coking and cold pressure and hot pressure coking technologies have been developed in the area of coking technologies, and research has been done on casting coke and iron alloy coke production technologies. Over the past few years, many coking plants have produced high quality casting coke which has promoted technical progress in the machinery manufacturing industry.

**C. Gasification**

There have been substantial developments in coal gasification technologies and China now has more than 4,500 fixed-bed regular pressure coal gasification ovens which use coal to produce low heat value fuel gas and synthetic gas. China's medium and small synthetic ammonia plants have been using fixed-bed water gas ovens to produce gas for use as a chemical industry raw material for a long time. Developments also have been made in technologies employing regular pressure fluidized-bed gasification to produce synthetic gas. The first generation Lurgi pressurized gasification ovens (2.7 m in diameter) imported from Czechoslovakia in the 1970's are still in regular operation. China's water gas ovens have used anthracite as a raw material since 1956, but later we also successfully studied the use of carbonated (lime) coal balls for use in chemical fertilizer production as shortages of block anthracite supplies appeared. A coal shaping technique developed by the Coal Chemistry Institute of the Coal Science Academy which uses humic acid salts as a bonding agent has enabled the four large Yangquan, Jingxi, Jiaozuo, and Jincheng anthracite mines to use powdered coal to make shaped coal used in gas production.

To expand the use of powdered coal as a raw material for gasification, the Shanghai Chemical Industry Research Academy, Chemical Fertilizer Institute, and other units studied fluidized-bed powdered coal regular pressure gasification technologies. A 5,000 ton yearly output synthetic ammonia industrial gasification oven was completed in 1983 and used in experiments with Longkou lignite, attaining the original design production requirements of 1,800 $Nm^3$/hour of water gas with $CO + H_2 > 80$ percent in the coal gas. Equipment operation has been excellent with the exception of a need to deal with corrosion problems in fire-resistant materials.

China has abundant lignite and high ash content bituminous coal resources, and the use of these types of coal as raw materials for complete gasification in the extraction of coal gas is one of the more important routes for urban coal gas development. In the past few years, we have adopted fixed-bed pressurized gasification and two-stage gasification to develop urban coal gas. Shenyang has completed a 540,000 $m^3$/day pressurized gasification plant (not yet in formal production). Now under construction is a 540,000 $m^3$/day pressurized gasification plant at Lanzhou and one at Yilan which will send 1.6 million $m^3$ of coal gas per day to Harbin.

To adapt to urban coal gas development, we have reinforced scientific research on coal gasification. China began studying fixed-bed pressurized gasification technologies in the early 1960's and built a 1.12 m diameter pilot pressurized gasification facility at the Shenyang Gasification Institute in 1964 to conduct gasification experiments with Shenyang lignite. A 650 mm diameter pressurized gasification experimental facility established at the Beijing Coal Chemistry Institute in 1984 has experimented with coal samples from five mining regions and provided a foundation for feasibility research or design for plant construction in the relevant cities. China also has designed and developed our own 2.8 m diameter fixed-bed pressurized gasification oven and gasification experiments are now in progress.

To adapt to the need to develop coal gasification in medium and small cities and towns and in mining regions, we also have studied two-stage water gas gasification, long flame coal gasification, and water gas partial

methanization technologies. Experiments with a 1.6 m diameter water gas two-stage gasification oven began in 1986. Fushun and Benxi coal is being used to make medium heat value coal gas, and progress has been pleasing.

Research on second generation gasification technologies is now proceeding smoothly, including a model experiment with an hourly processing capacity of 20 kg of coal which has been completed. Experiments using Tongchuan long flame coal are underway at a pilot facility with a scale of 1.5 tons/hour of coal, and rather good results have been obtained. the carbon conversion rate is 95 percent, the cold coal gas efficiency is 66 percent, and the effective gaseous $CO + H_2$ is 76 percent. Basic laboratory research has been done on powdered coal ash melting and extraction fluidized-bed gasification with the goal of producing low heat value coal gas, while anthracite and high ash content bituminous coal is being used in a 300 mm diameter experimental oven which processes 1 ton of coal to make 800 to 1,000 $kcal/Nm^3$ coal gas daily. The next step is intermediate testing.

**D. Coal liquefaction**

**1. Direct liquefaction of coal**

China did basic research on the first stage of coal liquefaction during the 1950's and early 1960's. New steps were taken in the early 1980's in research on direct liquefaction in China involving applied technical research on the direct hydrogenation of coal to convert it to a clean fuel. We cooperated with Japan to build a small experimental 0.1 ton/day continuous liquefaction facility, and a small experimental 5 kg/hour continuous liquefaction facility imported from West Germany is now operating. We also established and perfected various testing measures. It was discovered through systematic experimental research in the past few years that high sulfur content bituminous coal from Yanzhou and Tengxian in Shandong has excellent liquefaction properties and an oil output rate of up to 50 percent. Inner Mongolia and Yunnan lignite also have rather good liquefaction properties. Valuable progress has been made in selecting liquefaction catalysts, optimum technical conditions for liquefaction, liquefaction quality improvement processing methods, and other area. Chinese-made hydrogenation and reforming catalysts have been used in the laboratory, and we have developed high quality gasoline with an octane rating of 82.5 and chemical industry raw materials rich in aromatic hydrocarbons.

**2. Indirect coal liquefaction**

The Chinese Academy of Sciences Shanxi Coal Chemistry Institute has made substantial progress in research on Fischer-Tropsch synthesis. On the basis of completing basic laboratory research and 50 mm diameter single-tube experiments, intermediate testing at a chemical fertilizer plant with daily output of 100 kg of synthetic oil is underway using synthetic gas produced by a water gas oven employing a two-stage catalyst for synthesis and quality improvement at specific pressures to produce gasoline, coal gas, and other products.

In the area of coal-based substitutes for liquid fuels, several 10 units have experimented with methanol substitutes for gasoline over the past few years, and very good results have been obtained using M15 and M100 as a substitute for gasoline.

**E. Expanding new products using coal as a raw material**

There also have been developments in techniques using coal and its derivatives to make activated carbon, carbon fiber, and carbon materials. Output of activated carbon made from coal in China is about 10,000 tons. Very good economic results have been obtained in producing activated carbon powder using coal from high quality raw material coal producing regions. There also have been successful developments in extracting montan wax from wax-bearing lignite, using high quality anthracite to make granulated carbon, extracting divanadium pentoxide from bone coal, and other areas, and they have gone into production. We now have completed three montan wax production plants and six divanadium pentoxide plants, and the divanadium pentoxide is now being sold on international markets.

**Reinforce basic research work**

Research on coal quality is fundamental to comprehensive utilization of coal resources. The Beijing Coal Chemistry Institute has worked since the 1970's to reinforce research on standardizing coal quality analysis methods and it established a rather complete and integral system in the 1980's. In 1985, 45 state standards and eight ministry-issued standards received formal approval. China is now a member of the International Standardization Organization Solid Fuels Commission (ISO) TC-27, and we have participated in formulating international coal quality inspection standards. There are 20-plus types of coal testing instruments and 18 standard sample tests and standard materials which were jointly developed by the relevant departments and factories. They not only met the needs of the relevant laboratories in China but also have been sold in Thailand, Romania, and the United States.

Coal categories are an important basis for guiding coal development and utilization. In the early 1950's, China began to organize research on coal classification. In 1956 we proposed a "Chinese Coal Category (Focused on Coking Coal) Program" which was approved and applied by the State Science and Technology Commission in 1985 [as published]. This program has played an important role in 30 years of use but several inappropriate problems were gradually revealed during implementation. For this reason, the State Bureau of Standards organized more than 40 units in the coal, metallurgy, geology, and other areas for joint formulation of a new

coal classification program. More than 740 samples were selected and extracted according to coal formation regions and periods in China, and computers were used for large-scale computation and program comparison to provide a scientific basis for establishing category boundaries. The new coal classification program received state approval for trial implementation in October 1986. This classification program is more rational in demarcating various types of coal, and it provides a scientific foundation for effective coal utilization and pricing based on quality.

Over the past 30 years, the Beijing Coal Chemistry Institute has systematically formulated national and regional coal quality document collections which met the requirements of leading departments and production, scientific research, educational, and other units. Beginning in 1982, a national coal resource coal quality database was established with close coordination between the Computing Center at the Coal Research Academy and the relevant departments. It contains chemical experiment data on 5,200 coal samples and 6,500 records. Each record contains much data on physical, chemical, and technical properties which effectively serves the formulation of coal development and utilization policies and plans in China as well as users.

**II. Prospects for Coal Utilization**

Looking back at the past 30-plus years since the nation was founded, there have been substantial developments in coal utilization in China, but we lag behind the advanced industrialized nations in many areas. The main ones are a large amount of direct burning of coal, rather severe pollution, rather low coal heat energy utilization efficiency, insufficiently advanced coal utilization technologies, and railroad transportation shortages due to ever-increasing coal output. Thus, in accordance with principles stipulated by the government of China, we must place coal conversion and comprehensive utilization in an important status. Given the need to quadruple the value of industrial and agricultural output in China by the end of this century while merely doubling energy resource output, it is even more necessary to accelerate the development of rational and effective coal utilization. Attacks on key technical problems, technical transformation, and assimilation of technology imports should be closely integrated in a major effort to improve coal utilization techniques.

**A. Improve combustion technologies**

We must make further improvements in fluidized-bed combustion technologies, systematize coal burning equipment, attain higher combustion efficiencies, and continually study and perfect ash and slag utilization technologies.

China produces 3 million tons of coal slurry, and we must study techniques for developing coal slurry combustion and propose techniques and equipment suitable for burning coal slurry.

To achieve widespread development of shaped coal and a shift to shaped coal in urban fuels within the near future, we should concentrate forces to work on smokeless combustion technologies for bituminous shaped coal and high thermal efficiency shaped coal stoves.

High sulfur coal in China with a sulfur content in excess of 2 percent accounts for about 20 percent of coal output in China. We should actively develop new combustion technologies for power generation which meet environmental demands and techniques for desulfurization within fluidized-bed combustion ovens.

**B. Speed up the development of coal gasification**

There are few gasification technologies for production and civilian coal gas in medium and small cities and mining regions at present. Thus, the development of cheap and simple coal gasification technologies adapted to a wide range of coal types is an urgent task. We also should actively study advanced gasification technologies for producing synthetic raw material gas and industrial fuel gas and work to put them into industrial use as quickly as possible.

**C. Continue to study and develop coal-based liquid fuels**

China is extremely rich in coal resources suitable for coal liquefaction. Some regions like Yunnan, Shanxi, and others lack oil resources, so they have rather good prospects for developing coal liquefaction. Continue to do intensive research and expand the scale of experiments, and accelerate the pace of industrialization if the price of oil rises to a position which favors coal liquefaction.

Developing synthetic methane and low grade mixed alcohol technologies is an important aspect of developing $C_1$ chemistry, and it is an urgent need for dealing with the oil shortage in certain regions, so we should continue to give it an important status.

**D. Continue to improve coking technologies**

Although substantial advances have been made in China's coking industry, we still face difficult tasks. In the year 2000, there will be a substantial increase in iron and steel output, so we must strive to improve coking technologies and expand coal resources available for coking. China has accumulated experience in tamping coking techniques and we should continue to develop this type of technology in the future, including the adoption of large scale tamping coking techniques, in order to increase the proportion of powdered coal in the mix.

**E. Develop comprehensive utilization of lignite**

China has abundant lignite resources and now produces 3 million tons annually. This amount will increase each year in the future. We should actively develop lignite combustion and comprehensive utilization technologies to create the technical conditions for expanding the scope of lignite utilization.

## Solutions Sought For Coal Industry Shortfalls

*40100041c Beijing XINHUA in English 0857 GMT 6 Mar 89*

[Text] Beijing, 6 Mar (XINHUA)—China's coal supply is short of demand, and the scarcity may even grow worse if timely measures are not taken, PEOPLE'S DAILY reports today.

After 3 years' relief, the coal shortage has been growing worse since last year. East, northeast, and south China—the most important industrial and agricultural bases in the country—have asked for emergency supplies time and again, while national coal stocks have fallen steadily.

The strain may be felt for a long time as the shortage approaches 70 million tons in the Seventh 5-Year Plan (1986-90). National coal output is planned to reach only 1 billion tons in 1990.

By the turn of the century, China's demand for energy, after a 6 percent growth in the total value of industrial and agricultural output, will amount to 1.47 billion tons at least, and the shortage will increase as the coal industry lacks investment and new production facilities.

PEOPLE'S DAILY says that without timely investment, it will be too late to reverse the trend when the strain grows worse, as construction of a big or medium-size coal mine takes about 10 years.

Because of the shortage of investment, construction has started on coal mines with a total capacity of 49.92 million tons only. This figure is 83.8 million tons short of scheduled production for the first 4 years of the Seventh 5-Year Plan (1986-1990). Newly opened mines have a capacity of 89.91 million tons only, which is 42.21 million tons short of planned capacity.

The paper suggests that new sources of funds be found for the development of the coal industry, including local communities, foreign investors, and major coal users, instead of its having to depend on allocations from the Central Government only.

Rationalizing investment and tapping the potential of existing coal mines are important measures for increasing production. As mechanized mining accounts for only 30 percent of the state-run coal mines and 15 percent of local mines, improving management and technology will greatly increase production efficiency and output.

The price of coal is the most sensitive and vital question for the further development of coal production. Between 1949 and 1985, China's investment in the coal industry amounted to 7.89 billion yuan (20.51 billion U.S. dollars). The profits and taxes from the industry amounted to only 29.6 percent of the investment because of the unreasonably low price.

The price also forced major coal users and communities to reduce investment in the industry as well as putting mines in a dilemma, for most of them have suffered losses for years, or even decades.

The paper also suggests that workers' living standards be improved and their wages raised.

## Use of Low-Heat Value Solid Fuels Outlined

*40130045b Beijing BEIJING KEJI BAO in Chinese 26 Oct 88 p 3*

[Article by Ding Kun [0002 3540] and Wu Daorong [0702 6670 5554]: "Utilization of Low-Heat Value Solid Fuels in China"]

[Excerpt] [Passage omitted] Because coal is a solid fuel, poor quality coal is called a low-heat-value solid fuel. However, low-heat value solid fuels do not just include poor quality coal. Carbon shale, oil shale, bone coal, and coal gangue also belong to the category of low-heat value solid fuels.

The reason for the low heat value of these low-heat value solid fuels is that they contain little combustible carbon and hydrocarbon compounds, so they have a high ignition point and produce quite a bit of ash and cinder after combustion. Thus, boilers which burn high quality coal are unsuited to poor quality coal, so new types of boilers must be developed.

In the 1970's Zhejiang Province developed techniques for burning coal gangue in fluidized-bed boilers to generate electricity and they are now burning coal gangue, bone coal, oil shale, poor quality anthracite, lignite and other types. More than 2,000 fluidized-bed boilers of various capacities are used for power generation and residential heat supply. They can burn over 15 million tons of poor quality coal per year, which can save over 6 million tons of high quality coal. Statistics for 1986 from coal gangue power plants in the Yongrong, Pingxiang, Jixi, and other mining bureaus show that they already have seven coal gangue power plants which together generate 434 million kWh of power, a 38.2 percent increase in power generation over the 1985 figure of 120 million kWh. They earned 8.822 million yuan in profits, 2.15 times the 1985 figure. Some areas of Zhejiang, Hubei, Hunan, and other provinces with shortages of high quality coal also have developed civilian stoves which burn coal gangue.

"Fluidized-bed boiler" combustion has broken down the restrictions of "stratified combustion boilers" and "powdered coal boilers" in conventional power plants and achieved a partial solution to power supply in mining regions and coal-short regions. However, after fluidized-bed combustion of low-heat value solid fuels, 70 percent of the non-combustible matter is converted to cinders and discharged. This has made cinder processing an important issue. However, experiments and research indicate that the cinders, which have rather high silicon oxide and aluminum oxide contents, can serve as a raw material and aggregate. Moreover, experiments and research have shown that complete utilization of the cinders is possible and that coal gangue or bone coal can be processed and used directly to make cement and fired bricks, with the product quality of both meeting requirements. Usually, the strength of coal gangue bricks exceeds 100# and some can attain 200#. The cement is mostly 325# grade, some is 425#, and a little is 525#. According to incomplete coal system statistics, there are now about 141 coal gangue brick plants with a production capacity of 1.5 billion pieces/year. There are more than 20 bone coal power plants with an annual production capacity of more than 100 million pieces. There are nearly 100 gangue cement plants with an annual production capacity of more than 3 million tons. There are more than 50 bone coal cement plants with an annual production capacity of about 2 million tons. This is particularly important since coal gangue is a waste material discharged during coal extraction and dressing which takes up a great deal of land and pollutes the environment. Thus, coal gangue utilization can reduce gangue heaps, reduce the amount of land occupied, reduce pollution, convert waste into valuable material, and build up advantages while eliminating disadvantages.

The growth of S&T has led to continual development of broader and more intensive low-heat value solid fuel utilization. Useful elements can be extracted from it and processed into chemical industry products. The South China Mining Bureau and other units, for example, are using coal gangue to produce polymer aluminum and other chemical industry products. Zhejiang, Hunan, Hubei, and other provinces are using sodium method roasting techniques to extract divanadium pentoxide from bone coal. The Zhejiang Province Bone Coal Comprehensive Utilization Company built a vanadium refining plant with a 100 ton/year production capacity in 1986 which uses a fluidized-bed boiler ash and cinder vanadium extraction technique. The average divanadium pentoxide content of the ash and cinders averages 1.28 percent, the average conversion rate is 58.36 percent, the average leaching rate is 89.96 percent, the average vanadium precipitation rate is 95.0 percent, the average divanadium pentoxide recovery rate is 49.71 percent, and the taxes and profits per ton of divanadium pentoxide can exceed 7,800 yuan. The product is now being shipped to and sold in foreign countries. Organic solvent extraction techniques are used to extract montan wax from lignite, which has satisfied market demand. In the area of peat utilization, peat fibers are being used to treat waste water from cation textile printing, humic acid is being used as a soil improvement agent, and so on.

Low-heat value solid fuels have achieved rather widespread utilization and that there will be even broader prospects for their utilization following future developments in combustion technologies, a more profound understanding of the world of microscopic matter, and high tech applications.

China has been quite concerned with survey work related to low-heat value solid fuel resources. Surveys indicate that most bone coal is found in Zhejiang, Jiangxi, Hunan, Guangdong, Guangxi, and other provinces (and autonomous regions) which have shortages of high quality coal. Bone coal also can be found in provinces rich in high quality coal like Anhui, Henan, Shaanxi, and Guizhou. Total reserves are about 61,876.7 million tons, with proven reserves of 3,897.3 million tons. Lignite is found mainly in Inner Mongolia, Heilongjiang, Jilin, Liaoning, Hebei, Shandong, Guangdong, Guangxi, Sichuan, and Yunnan. They contain reserves of 84.001 billion tons, equal to 14.1 percent of China's total coal reserves. Most oil shale is located in Liaoning, Jilin, Guangdong, and some parts of Shandong. Projected reserves are 400 billion tons. According to partial surveys, peat resources can be found in 704 counties, with total reserves of 27 billion tons. China has a large amount of coal gangue, with gangue discharges accounting for 10 to 15 percent of raw coal output. This includes about 15 to 20 million tons of washing gangue annually. The amount of gangue which has accumulated over the years exceeds 1 billion tons. As coal production develops, gangue discharges will continue to increase each year. This abundant resource offers vast prospects for using low-heat value solid fuels, and unified planning policies to encourage continued extraction will create even greater material wealth for socialist construction.

## Shaanxi Resources Now Second Largest in Nation

*40130078c Xi'an SHAANXI RIBAO in Chinese 7 Jan 89 p 1*

[Article by Li Yansheng [2621 1693 0524]: "Shaanxi's Total Coal Resources Second Largest in China"]

[Text] The "Collected Survey Reports on Coal Resource Prospects in Shaanxi Province" examined and approved by the Ministry of Geology and Mineral Resources and the Shaanxi Provincial Bureau of Geology and Mineral Resources show that total coal resources in Shaanxi Province exceed 900 billion tons, second largest in China after Xinjiang. This major achievement was made by the Eighth Geological Team in the Shaanxi Provincial Bureau of Geology and Mineral Resources.

On the basis of detailed research and existing data, this report demarcated 39 forecast regions to estimate reserves. They calculated proven reserves for different coal types and reserve grades. Projected coal resources of

all grades in Shaanxi are 748 billion tons with total proven reserves of 909.6 billion tons. Coal resources centered on the five big coalfields in north Shaanxi and north of the Wei He account for over 99.9 percent of total projected resources in Shaanxi. Achievements in the Yulin and Hengshan survey regions and the Jingbian-Dingbian forecast region show that the Jurassic coalfield in north Shaanxi is an enormous coalfield with excellent quality coal. It is an important part of the huge Jurassic era Ordos coalfield, among the world's largest, which stretches across Shaanxi, Gansu, Ningxia, and Inner Mongolia provinces and autonomous regions. It and the Fugu mining region in the Carboniferous-Permian coalfield of north Shaanxi will become a coal industry base area on an even larger scale in Shaanxi Province. It may have petroleum and natural gas resources linked to the Ordos Basin, forming a new type of comprehensive energy resource base area. It will have far-reaching effects on energy resource construction in China and development of western regions.

## Anhui Takes Steps To Relieve Worsening Energy Situation

*40130078b Shanghai JIEFANG RIBAO in Chinese 19 Feb 89 p 1*

[Article by special reporter Wang Jiasi [3076 1367 7475]: "Anhui Working To Protect Coal-Fired Power Output at Huainan and Huaibei, Handle Things According to Facts, Encourage Real Effort"]

[Text] To deal with the growing energy shortage in east China, the Anhui Provincial CPC Committee and Provincial Government used the overall situation as a basis for an all-out effort to guarantee coal and electric power production at Huainan and Huaibei. They are providing solid services to coordinate coal and power departments in Huainan and Huaibei, supporting increased coal and power output at Huainan and Huaibei, and assisting economic construction in Anhui and east China.

Huainan and Huaibei are east China's biggest energy resource base areas. The Huainan and Huaibei mining regions now have 27 producing mines with annual coal output in excess of 23 million tons. Another six mines under construction have a design yearly coal output of 13 million tons. However, coal production has been affected because old mines at Huainan and Huaibei are aging more quickly due to the high intensity of extraction, construction of new mines has been slowed due to complex geological conditions, and there have been two breaks in mine construction. In the area of electric power production, Anhui's main generators are concentrated at Huainan and Huaibei with an installed generating capacity of 2.4 million kW, making it an important part of the east China Power Grid. The coal shortage has forced many generators in east China to shut down, causing frequent power restrictions and power shut-offs to enterprises in Anhui and east China which have affected industrial and agricultural production and the people's livelihood.

Huainan and Huaibei are located in Anhui, so Anhui has the responsibility for pushing forward with coal-fired power production and construction at Huainan and Huaibei. For this reason, the Anhui Provincial CPC Committee and Provincial Government established a special leadership group to guide and coordinate work at Huainan and Huaibei. Lu Rongjing [4151 2837 2529] and other leading comrades in the Anhui Provincial CPC Committee and Provincial Government did extensive underground survey research in the Huainan and Huaibei mining regions. At the same time, Fu Xishou [0265 6932 1108], Shao Ming [6730 2494], and other Anhui Provincial vice governors went to the Huainan and Huaibei energy resource base areas to set up on-site offices to deal with several problems like requisitioning land and dismantling and removing facilities which had gone unsolved for a long time and were affecting construction progress. This gave coal mine leaders time to engage in coal mine production and construction work.

Given the present electric power shortage, the Anhui Provincial Government decided to provide power to coal mines, and although some local interests were sacrificed, it did assure continued progress in coal mine production and construction. The Huainan and Huaibei Prefectural CPC Committees and Prefectural Governments also have focused their work on protecting coal-fired power and they are striving to serve coal mine production and construction.

The attention and support given by the Anhui Provincial CPC Committee and Provincial Government to energy resource development and construction at Huainan and Huaibei has encouraged the 300,000 cadres and employees on the coal and electric power battlefronts in Huainan and Huaibei to work harder. In January 1989, Huainan and Huaibei together supplied 2.01 million tons of coal and generated 1,021.5 million kWh of electricity, exceeding both coal and power production plan quotas assigned to Huainan and Huaibei by the state.

## Head of Petroleum, Natural Gas Corporation Discusses Industry Trends

*40130067b Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 13 Jan 89 p 1*

[Article: "Wang Tao Discusses Overall Petroleum Industry Development Plans"]

[Text] President of the China Petroleum and Natural Gas Corporation Wang Tao yesterday stated at a national petroleum industry meeting that this year, oil and gas prospecting, development and construction must be accelerated under the adverse conditions of a severe shortage of funding and that crude oil and natural gas production must continue developing amid the difficulties of a planned loss policy.

According to the plans stated at the meeting, oil and gas prospecting must result in 600 million tons of proven geological reserves of oil and another 600 million tons of controlled reserves during the year, in addition to 40 billion cubic meters of proven geological reserves of natural gas and 37 billion cubic meters of controlled reserves. In addition, while the primary focus will continue to be on the eastern regions, prospecting in western regions must be accelerated and an effort must be made to achieve major breakthroughs in several critical regions in order to pave the way for future increases in reserves and output.

As regards the establishment of productive capacities, the construction of eight oilfields in the 1 million tons/year class and eight more in the 100,000 tons/year class will be begun or continued this year, and arrangements are being made for construction of 165 million tons/year of crude oil production capacity and 600 million cubic meters/year of natural gas production capacity.

It is planned that the national output of crude oil will be 139-140 million tons and that of natural gas will be 14 billion cubic meters. A vigorous effort must be made to reach the upper figure in crude oil production and to implement the request of the party Central Committee and the State Council that national output of crude oil be increased by 3 million tons a year; and a vigorous effort must be made to set new records in natural gas production.

To deal with the shortage of funding, this year the oil and gas prospecting industry will shorten its battle lines, concentrate its forces, and make breakthroughs at the key points. Efforts must be made to add about 700 million tons of proved and controlled geological reserves of petroleum in the Shengli, Liaohe, Zhongyuan, Dagang, and Huabei oil regions; prospecting must be expanded in the new prospecting regions of the eastern Junggar Basin, the Chalu He region in Jilin, the Nanbao area of eastern Hebei, and the southern Kongdian area of Dagang; and prospecting must be stepped up in the beach areas and extremely shallow areas of the Bohai Wan, primarily the Chengdao structure and the structures south of the Haiwai He. Natural gas prospecting must be intensified in Sichuan, the area surrounding Daqing, the eastern Qaidam area, and the Shaanxi-Gansu-Ningxia region in an effort to continue making major discoveries.

Major efforts must be made to expand mature, advanced and practical processes and technologies, integrate them fully into the system and make them factors in production. In the Tarim Basin, which is the central focus of this year's new areas for oil and gas exploration, new processes and technologies and new management systems will be used to organize an advanced, highly cost-effective campaign of petroleum exploration and development.

Wang Tao emphasized particularly that the petroleum industry has great unused potential and that it must genuinely focus efforts to develop production on making use of internal potential and vigorous discovery of resources and conservation, convert loose and careless operation into precise operation and strict budgeting, and use every means possible to increase economic benefits.

## New Oil and Gas Reserves Discovered

*40100039b Shanghai SHANGHAI FOCUS in English 13 Mar 89 p 1*

[Article by our staff reporter Xu Yuanchao: "China's Oil Sector Discovers New Oil and Gas Reserves"]

[Text] Oil industry officials say China is facing a boom in oil and gas exploitation. The discovery of new reserves in six different areas has been reported recently.

The China National Petroleum Corporation (CNPC) and the Ministry of Geology and Mineral Resources say China's proven oil deposits have been increased to 16 percent of the country's total oil resources over the past 40 years. Estimates of the resources range from 61.4 billion tons to 78.7 billion. There is large potential to tap.

Geologists estimate that China has gas reserves of 2,600 to 3,300 billion cubic metres. They have already located about 70 billion cubic metres, or 2.6 percent of those resources.

Chinese experts once worried about whether there were enough reserves to sustain the oil industry and to give impetus to the further development over the next five years.

The new oil deposits are likely to reach 2.6 billion tons, of which 530 million tons have been proven. Another 500 million tons of oil reserves are expected to be verified over the next two years. Reports from the China National Petroleum Corporation say that the new reserves are in the eastern part of the Zhungur Basin in the Xinjiang Uygur Autonomous Region, near the town

of Chalube in Jilin Province, in the area south of Kongdian, Dagang Oilfield, in the vicinity of Nanbao in eastern Hebei Province, around Erlian in Inner Mongolia and around Lake Duoskuhle in Qinghai Province.

Another 12 oil-bearing areas around major oilfields of Daqing, Shengli, Liaohe, Xinjiang, Dagang, Zhongyuan and North China are estimated to contain 2 billion tons of oil, of which 1.2 billion have been verified.

In China's offshore areas, oil companies have found an 80-square-kilometre shoal near the Bohai Bay. The two exploratory wells tested there were found to produce an estimated 100 cubic metres of oil a day. Another well hit an oil reservoir approximately 200 metres thick, which is likely to contain more than 100 million tons of oil.

The China National Offshore Oil Corporation, a State-owned company in charge of searching for oil on China's continental shelf, has discovered an oilfield with proven reserves of more than 100 million tons within an area of 30,000 square kilometres in the basin at the mouth of the Pearl River in the South China Sea.

A large gas field found in Sichuan Province is estimated to hold more than 10 billion cubic metres of gas. A few gas fields have also been found at the eastern part of the Zhungur Basin in Xinjiang and in the Sanzhao area of the Daqing oilfield.

Oil experts say that aggregate oil deposits in the country's 194 oilfields in operation in 1988 have dropped by 50 percent. The water content in oil reservoirs is over 70 percent.

Output is declining in a number of oilfields which played extremely important roles in China's oil production in the 1970s.

## Tarim Said Best Bet in Search for Paleozoic Oil and Gas Deposits

*40130046 Beijing ZHONGGUO DIZHI [CHINA GEOLOGY] in Chinese No 10, Oct 88 pp 17-18, 20*

[Article by Kang Yuzhu [1660 3768 2691] of the Ministry of Geology and Mineral Resources Northwest Petroleum Geology Bureau: "Tarim Basin Is the Best Region to Search for Oil and Gas Deposits in China"]

[Text] More than 30 years of oil and gas survey and exploration work in the Tarim Basin has produced rich petroleum geology data and achievements. Before the 1970's, however, the primary target strata for prospecting were from the Mesozoic and Cenozoic eras.

We suggested in 1978 that the Carboniferous-Permian and Cambrian-Ordivician systems were important oil and gas generating and reservoiring rock systems. In 1980, oil-bearing rock cores were obtained from Carboniferous limestone at the Mai No 1 parameter well drilled on the slope of Maigaiti. Next, the Ministry of Petroleum Industry drilled the Qu No 1 well in 1980 and discovered a small amount of crude oil in middle and upper Carboniferous system rock. This confirmed without a doubt that the Carboniferous system generated and reservoired oil and gas. In September 1984 a high output industrial oil and gas flow was obtained in more than 5,300 m of Ordivician dolomite in the Tankelao structure of the Shatan uplift in northern Tarim Basin. This was the first major breakthrough with Paleozoic marine facies oil and gas deposits in China and opened up new ideas concerning the search for oil. It brought earthshaking changes to oil and gas exploration work at Tarim and some experts and scholars began to focus on the search for Paleozoic marine facies oil and gas.

We have done extensive research on the Paleozoic at Tarim over the past 2 years and made preliminary comparisons with the geological conditions of Paleozoic oil and gas in east China. We now believe that Tarim is one of China's best regions to explore for Paleozoic marine facies oil and gas fields (deposits). The basis is as follows:

### I. Oil and Gas Generation and Reservoiring Conditions

1. Tarim contains oil and gas generating strata from many eras and strata systems. They are the upper Sinian, Cambrian, Ordovician, lower Silurian, Carboniferous, and Permian systems. The main oil generating rock includes dark muddy shale, limestone, dolomite, and other types. The total thickness of the oil generating rock is 1,000 to 3,000 meters. The geochemical indices of the oil generating rock are organic carbon (C) 0.2 to 2.42 percent and chloroform bitumen (A) 85 to 772 ppm. Preliminary calculations of resources exceed 10 billion tons.

Paleozoic reservoir rock is extremely well developed at Tarim and strata of all eras can reservoir oil and gas. The reservoir rock includes both clastic rock and carbonate rock types. Moreover, oil and gas indications or oil and gas flows to varying extents have been seen at the surface and in many wells. The reservoir strata in the oil and gas deposits at Yakela on the Shaya uplift, for example, are from the upper Sinian, Cambrian, and Ordovician systems. Fissure bitumen, crystal cavity heavy oil, oil-bearing sandstone, and so on have been found in the Cambrian to Permian systems on the Kalpin uplift, Kuruktag uplift, and other areas. Oil and gas indications or small amounts of crude oil and gas were discovered in the upper Devonian and Carboniferous systems at wells on the Bachu uplift and Maigaiti slope. These confirm the extremely excellent Paleozoic oil and gas generation and reservoiring conditions of Tarim.

2. Oil and gas generation and reservoiring conditions in south China (the Yangzi paraplatform and South China paraplatform) also are extremely ideal. The oil generating rock systems there include the Cambrian, Silurian, Devonian-Carboniferous, and Permian-middle Triassic systems (however, the lower Paleozoic of the South

China paraplatform underwent metamorphosis and lost its oil generation value). The primary oil generating rock is dark muddy shale, limestone, dolomite, and so on. The oil generating strata have a total thickness of 1,000 to 4,500 meters. The geochemical indices of oil generation are organic carbon 0.097 to 1.91 percent, chloroform bitumen (A) 240 to 740 ppm, and hydrocarbon 121 to 418 ppm. Preliminary resource calculations are 6.5 trillion $m^3$ of natural gas (and about 100 million tons of petroleum).

Paleozoic marine facies reservoir rock is also extremely well developed in south China and all systems can reservoir oil and gas. There are now more than 1,000 sites at which oil and gas indications to varying degrees have been found in the Sinian, Silurian-Devonian, Carboniferous-Permian, and middle and lower Triassic systems and several ten gas deposits have been discovered. All this shows that the oil and gas generation and reservoiring conditions in south China are rather good.

3. The North China platform: the Paleozoic upper Ordovician and lower Carboniferous systems are absent. The primary oil generating rock in the region is from the Cambrian and the middle and lower Ordovician systems. The middle and upper Protozeroic groups (the Changcheng, Jixian, and Qingbaikou systems) also have oil generating properties. The oil generation lithology is dark muddy shale, limestone, dolomite, and so on. The total thickness is 600 to 2,000 meters. The geochemical indices of oil generation are organic carbon 0.1 to 0.26 percent and chloroform bitumen (A) 0.015 to 0.07 percent. The projected oil and gas resources are far smaller than those of the Tarim platform and south China.

The North China platform still may have the conditions for reservoiring. Oil and gas indications have been seen at several sites in the middle and upper Protozeroic and the middle and lower Ordovician systems. Moreover, several oil and gas deposits have been found in the middle and lower Ordovician system (oil and gas generated in the Tertiary was reservoired downward in these systems).

**II. Degree of Oil and Gas Evolution**

1. The temperature gradient at Tarim is generally 1.9° to 2.5° C, which is lower than in east China. Previous data on xylovitrain refractivity shows the Carboniferous system $R_o$ to be 0.91 percent, and the conodont is yellowish-brown in color. Moreover, high output oil and gas flows generated and reservoired in the same rock were seen in the Cambrian and Ordovician systems at a depth of more than 5,300 meters in north Tarim. Thus, the evolution of oil and gas at Tarim belongs to the mature-highly mature stage.

2. The temperature gradient of the Paleozoic (including the lower and middle Triassic system) in south China is generally 3° to 4° C. The previously measured xylovitrain refractivity $R_o$ of the middle and lower Triassic is 1.5 to 2.5 percent, with a maximum of 3 percent. The Triassic system in the Jurong region of Jiangsu belongs to the highly mature-overly mature category. In summary, most of this region belongs to the highly mature-overly mature stage, and has generated mostly gas. Natural gas deposits were discovered there over several years of work.

3. The temperature gradient in the North China platform is 3.3° to 3.9° for the Cenozoic, usually 3.7° to 4.2° for the Mesozoic, and 3.9° to 4.5° for the Paleozoic. Inferring from this temperature gradient data, the lower Triassic system of the Cenozoic is in the mature stage, while the Mesozoic and Paleozoic are in the highly mature-overly mature stage, so only primary gas deposits will be found in the Paleozoic and the middle and upper Protozeroic.

To summarize, the degree of Paleozoic oil and gas evolution in the Tarim region is the mature-highly mature stage, which is superior to east China.

**III. Oil and Gas Preservation Conditions**

1. Sedimentation ceased during the Paleozoic in Tarim. It underwent a brief hiatus and erosion and then was quickly covered by widespread and enormously thick Mesozoic and Cenozoic groups. Only the margins of the platform at the Kalpin, Kuruktag, Tiklik, Arjin, and other uplifts were exposed for long periods. Thus, the region's capping strata conditions also are extremely ideal.

Second, the Indosinian and Yanshan movements were not very intense throughout the region, and only at the margins of the region is there contact at an unconformable angle between the Cretaceous and Jurassic systems. There also are no indications of magmatic activity, so there was no destruction of Paleozoic oil and gas.

Although Xishan movement was extremely intense in the Tarim region (magmatic activity, however, was very weak), it had significant effects only on the margins of the region and played no role in destroying Paleozoic oil and gas throughout most of the region.

All this shows that the Paleozoic oil and gas preservation conditions are extremely good at Tarim.

2. After Paleozoic and middle Triassic system sedimentation in south China, most of the region was exposed at the surface and eroded. Rather thick Mesozoic and Cenozoic groups developed only in the Sichuan, Jianghan, north Jiangsu, and other regions and they became excellent capping strata for the Paleozoic. Currently, oil and gas plays at more than 1,000 sites and several bitumen veins have been seen in the vast Paleozoic outcrop region, providing traces which indicate that Paleozoic oil and gas pools have been destroyed.

Second, the evolution of Paleozoic oil and gas in south China is in the overly mature stage and mainly generated gas. This places extremely strict demands on capping strata. The pore diameter of capping strata must be less than 0.5 μm before they can serve as a capping strata for gas, whereas a pore diameter of 2 μm is sufficient for crude oil capping strata. Thus, it is very hard for natural gas to be preserved by rather thick and excellent capping strata.

Third, the Indosinian and Yanshan tectonic movements were extremely intense, and there was a great deal of associated magmatic activity. This pierced and fragmented the Paleozoic in the southeastern part (Zhejiang, Jiangxi, Fujian, Guangdong, and other provinces and autonomous regions), completely destroying the oil and gas generated in the Paleozoic.

Fourth, structural uplifting and fracturing in this region led to extremely active hydrodynamic effects in the region. They changed the difference in drainage region potential and caused the surface water and underground water to switch, which was extremely unfavorable for oil and gas preservation and often became one reason for the destruction of oil and gas pools.

These points show that the oil and gas preservation condition in south China are not good, but this does not mean there is no hope of finding oil and gas outside already-discovered gas pools within the region.

3. The North China platform was intensely uplifted after middle Ordovician sedimentation and underwent a long period of weathering and erosion. It was not until the late Carboniferous period that it began to receive sediments. Thus, it would have been very difficult for oil and gas generated prior to the middle Ordovician to be preserved due to the long period of weathering and erosion.

Moreover, Indosinian and Yanshan activity were extremely strong in this region and there was great deal of associated magmatic activity, so the destructive effects on oil and gas pools already formed in the Paleozoic cannot be underestimated. Still, it may be possible to find gas pools in regions with better preservation conditions.

To summarize: 1) Oil and gas generation and reservoiring conditions indicate that south China and the Tarim region are the best, while the north China platform is rather poor. 2) Thermal evolution conditions of the oil and gas indicate that the Tarim platform is the best and is in the mature-highly mature stage, while south China and the North China platform are rather poor, in a highly mature-overly mature stage, and generated mostly gas. 3) The oil and gas preservation conditions are best on the Tarim platform but rather poor in south China and the North China platform.

Thus, Tarim is the best region to search for Paleozoic marine facies oil and gas deposits in China.

While writing this article I used related reports by the Southwest Petroleum Geology Bureau and comrade Liu Xiang [0491 0686], and I would like to express my gratitude.

## Sichuan's Oil, Gas Fields See Steady Increase in Output

*40130071b Chengdu SICHUAN RIBAO in Chinese 30 Dec 88 p 2*

[Article: "Production at Sichuan's Oil and Gas Fields Makes Great Strides"]

[Text] Guided by the principles of reform, opening and invigoration, oil and gas field construction in Sichuan has made great strides. The number of wells drilled has increased by 72 percent over the figure 10 years ago, and well drilling footage has increased by a factor of 1.3. The number of wells striking gas has doubled, the output of crude oil has increased by 73 percent, and sulfur output has risen by a factor of 3.5.

In recent years, the state has instituted natural gas output and commodity-factor contracting with oil and gas fields under Sichuan's Petroleum Management Office, has twice adjusted the price of natural gas, and has instituted a compensation price for above-quota gas production. It has agreed that the enterprises may draw some bonus funds from the prospecting and development fund, and has instituted the major policy of "letting gas earnings support gas development" and of raising funds for oil and gas prospecting and development. The result of these policies has been that the average annual investment figure has increased by a factor of 1.2 thus infusing Sichuan's natural gas industry with new vitality. In turn, while making enterprise reform more thorough, the oil and gas fields have gradually established various contracting and economic-responsibility systems that link together responsibilities, rights and benefits, have transferred some management authority to lower levels, have undertaken spot experiments in internal planning and small-scale accounting units, project management, and internal conversion to enterprise status, has developed lateral economic ties within and outside the enterprises, and has gradually implemented the plant manager responsibility system. As a result of these reform measures, the enterprises have begun to change over from the production model to the production management model and the economic operations mechanism has begun to take the form of control on the macroscopic scale and invigoration on the microscopic scale.

As a result of an increase in autonomy with regard to raising and utilization of funds, they can rely on internal savings for a certain degree of self-reform and self-development; for the past several years the provincial petroleum management office has imported and improved technologies and equipment, has hired more than 10 foreign companies to provide technical services in Sichuan, has engaged in technology exchange with petroleum experts in more than 20 countries and

regions, and has developed and put into use such new processes and technologies as distinctively Sichuan-style balanced well drilling, well control, and antideviation measures, high-pressure jet well drilling, high-efficiency drill bits, "three-sulfur" drilling mud, Sichuan-style coring tools and clustered deviated wells, which have increased the speed and quality of well drilling and have promoted a continuous increase in backup reserves of natural gas. The total amount of production-facilities construction in the 10-year period is twice the total amount in the 28 years preceding the Third Session of the Eleventh CCP Central Committee. In the area of diversified operations, products including drill bits, sulfur, instrument grease, paraffin and brake fluid have entered international markets, and several dozen branch units are providing labor and technical services on domestic oilfields and in Iraq. The aggregate economic benefit from all of the management office's enterprises is rising steadily. Enterprise investment in the construction of production facilities has changed from a primary focus on state allocations to a primary focus on the raising of their own funds. Total industrial output value in 1987 was 60 percent higher than the 1977 figure, finance payments were up by a factor of 6.35, and profits had increased by 71.7 percent.

## Plans for Second Daya Bay Plant Denied

*40100043b Hong Kong HONGKONG STANDARD in English 8 Apr 89 p 2*

[Article by Ma Miu-wah and Adrian Cheung]

[Text] China has told the British Embassy in Beijing that a rumoured second nuclear power plant at Daya Bay will not be built. But local legislators still want official confirmation from the Chinese authorities.

The Legislative Council unanimously expressed strong objections to any plan to build a second power plant at Daya Bay at its in-house meeting yesterday before the denial from Beijing came in. But members reacted by requesting an official statement from China.

Legco's response reflected disquiet in the community which they thought would not be assuaged without a direct answer from China.

The British Embassy took the initiative earlier this week in raising the question with Beijing after strong opposition in Hong Kong to the plan by local legislators, academics, and community leaders.

The plan was first reported last Thursday when Mr Jiang Shengje, a technical adviser to the Chinese Nuclear Industry Development Corporation, was quoted as saying the Chinese authorities were considering an initial $23.4 billion investment in a second power plant at Daya Bay.

But the British Embassy yesterday said those reports were false.

"We understand that the press reports concerning a second power plant in Daya Bay are untrue," Mr Peter Davies, Press Secretary at the Embassy told THE HONGKONG STANDARD yesterday. Asked whether the decision not to build a second power plant would be firm, Mr Davies said it would be—at least for the moment.

At the in-house meeting, Legco specially raised reports of the proposed extra power plant for discussion and were unanimous in objecting to it.

But the Council had not received the message from the Embassy until Councillor Mr Hui Yin-fat was briefing the press on the outcome of the meeting.

"The message has only just been released by the British Embassy," said Mr Hui. "We hope it will be officially confirmed by the Chinese Government."

Mr Hui said senior member of the Legislative Council, Mr Allen Lee Peng-fei had already discussed the question with the Governor Sir David Wilson and the Chief Secretary Sir David Ford.

The controversy was sparked last Thursday by Mr Jiang, who gave such a detailed account of the plan for a second power plant—including budget, location, date of commissioning and safety plans—that it was understood to be a firm plan.

Mr Jiang said two 1,000-megawatt Soviet pressurised water reactors could be completed at Daya Bay by 1995.

This led a chorus of calls to drop the plan from local members of the Sino-Hong Kong Nuclear Safety Consultative Committee, the Joint Conference for the Shelving of the Daya Bay Plant and individual Legislative Councillors.

But a denial from China's Energy Ministry under the State Council three days ago created confusion.

Mr Wang Wenze, spokesman for the Ministry, said it had not asked Guangdong Province to conduct any feasibility studies, nor had it authorised Mr Jiang to announce any plan.

## Nuclear Energy Could Play Role in Easing Power Shortage in East

*40130067c Shanghai JIEFANG RIBAO in Chinese 5 Jan 89 p 3*

[Article: "Nuclear Power Is the Proper Orientation of East China's Power Industry"]

[Text] Following an inspection of the Qinshan nuclear power plant and certain power generating enterprises in East China, Minister of Energy Huang Yicheng said during an exchange of opinions with the leadership of the Zhejiang Province government that construction of stage 1 of the Qinshan nuclear power plant must be stepped up and the scale of the project must be expanded. Developing nuclear power is the proper orientation of East China's power industry.

Huang Yicheng stated that in and about the year 2000, coal will still be China's basic energy source, but that every effort must be made to develop usable fossil-fired and hydroelectric power resources in East China. Under the current resource situation, we can develop 10 million kW of generating capacity using nuclear power, and developing nuclear power is the proper orientation of power development in East China. Nuclear power is currently in its initial stage and construction costs are rather high. The cost ratio of fossil-fired to nuclear power abroad is about 1 to 1.2, while in China it is 1 to 4 or even 1 to 6. We must import advanced foreign technologies and establish the domestic production of equipment. We are confident that the construction cost of nuclear power plants can be decreased and we are making vigorous efforts to shorten construction times. The construction on the Qinshan power plant will include three stages, and a nuclear power center will be established there. Qinshan's first 300,000-kW unit must be in operation in 1990.

Huang Yicheng stated that the future orientation of electric power development is for the center and the localities to pool resources for power development, and nuclear power is included. The national Ministry of Electric Power will vigorously support East China's efforts to raise funds for nuclear power and will help solve the problem of inadequate funds.

## Qinghua Low-Temperature Nuclear Heat Supply Project Nears Completion

*40130071a Beijing KEJI RIBAO in Chinese 18 Feb 89 p 1*

[Article: "Construction on Qinghua University's Experimental Low-Temperature Nuclear Heat Supply Reactor Completed"]

[Excerpt] The 5-MW experimental low-temperature heat supply reactor being designed and built by Qinghua University's Research Institute of Nuclear Power Technology has entered the final stage of construction, installation of most of the process systems has been completed, and trial operation will be begun soon.

The low-temperature heat supply reactor is a key project of the Seventh 5-Year Plan. It will use nuclear power for centralized municipal heat supply, representing a new aspect of the peaceful use of nuclear power. Heat supply accounts for a rather large proportion of energy expenditures: in 1980, of the 603 million tons of commercial standard fuel expenditure in China, heat supply accounted for 400 million tons, more than 3 times the amount spent on electric power generation. With China's coal and petroleum supplies decreasing, with the problem of coal transport becoming increasingly prominent, and with coal combustion producing serious urban pollution, nuclear heat supply is an effective solution. A reactor with a thermal output of 450,000 kW, supplemented by a boiler plant to cover peak loads, can provide heating for 10 million square meters of building space.

Low-temperature heat supply reactors have the advantages of using simple equipment, requiring low investment and having short construction periods, and in addition they save coal, do not pollute the environment as coal-fired boiler plants do, and supply heat more cheaply. It is tentatively estimated that the cost of nuclear heat supply is about 30 percent lower than that of boiler heat supply.

Construction of the Qinghua University Research Institute of Nuclear Power Technology's 5-MW experimental reactor for low-temperature heat supply began in March 1986. All construction work has now been completed, and 13 process systems and units have been installed. Installation of the remaining four systems is in progress; in addition, 13 important tests have been completed, and inspection and approval by the State Nuclear Safety Office is under way, and preparations for operation are being made. This reactor uses low temperatures, low pressures and low power densities; it uses natural circulation, has no moving parts or valves, does not depend on external electric power sources for cooling, has a unitized structure, has no primary-circuit water piping external to the reactor and no pumps and valves, uses a double pressure containment shell, and is provided with an intermediate isolating circuit, making it quite safe and reliable. The hydraulic drive mechanisms of the reactor's control rods have won the first state patents, and both cold and hot tests have now been successfully completed.

On 2 February, Comrade Song Jian and others inspected the scientific and technical development results of Qinghua University's Nuclear Power Institute, observed the shielded reactor that the university built in 1964 and the soon-to-be-completed 5-MW experimental low-pressure nuclear heat supply reactor, a valve testing circuit, a control rod test bench, development facilities for the clad fuel pellets and fuel elements of a high-temperature gas-cooled reactor, and a precision ceramic laboratory. [passage omitted]

## Design of 300-MW Nuclear Power Plant Steam Turbine

*40130063a Shanghai DONGLI GONGCHENG [POWER ENGINEERING] in Chinese No 6, 15 Dec 88 pp 1-7*

[Article by Gao Shuqiang [7559 2885 1730] and Li Yuanxi [2621 6678 6932], Shanghai Steam Turbine Plant: "Design of a 300-MW Nuclear Power Plant Steam Turbine"]

[Text] Abstract: The design characteristics of a 300-MW nuclear power plant steam turbine are summarized, including: (1) inclusion of a separator-reheater unit; (2) effective internal moisture removal measures; (3) a variety of erosion-prevention measures; (4) choice of appropriate materials for key components; (5) effective and reliable means of preventing excessive overspeeding.

### I. Introduction

The Project 728 steam turbine project documentation meeting held in July 1982 at Shanghai chose an operating speed of 3,000 rpm for China's first domestically designed 300-MW nuclear power plant steam turbine and agreed to the adaptation of imported fossil-fired generating unit technology for the nuclear power plant unit. This is a product based on the principles of safety, reliability and economy, that will assure that project schedule is adhered to and will be produced on time and meet specifications.

Making use of mature data on imported technology for 300- and 600-MW fossil-fired power plant steam turbines, the medium pressure unit of a 600-MW fossil-fired power plant steam turbine (BB 051 module) was modified for use as the high-pressure unit of a 300-MW nuclear power plant steam turbine. This was done

because the intake volume flows of the high-pressure turbine units for nuclear power plants are only 41 percent as great as those of the medium-pressure units of fossil-fired power plants, so that suitably decreasing the blade height in the steam passage and making modifications suited to the characteristics of nuclear power plant generating units is entirely feasible. In the case of the low-pressure unit, the steam intake and exhaust characteristics of nuclear and fossil-fired units are basically the same, the steam intake flow and insulation enthalpy drop differ only slightly, and the mass flows differ by only 1 percent, so that only minor modifications of the BB 074 module are needed to meet the requirements of nuclear power plants.

In addition, in order to make full use of mature designs and successful experience with fossil-fired steam turbines to increase operating reliability, the intermediate reheat steam valves of the 600-MW steam turbine unit were modified to form a main steam valve suitable for a nuclear unit.

These are the basic design concepts for the 300-MW nuclear power plant steam turbine.

The expanded preliminary design evaluation for the Project 728 steam turbine generator unit, held by the State Economic Commissions in April 1983, approved the general design for the steam turbine unit proposed by our plant, involving: two low-pressure units and a single high-pressure unit, with two steam separator-reheater units, a feedwater regenerative heating system consisting of three high-pressure units, one low-pressure unit and a deaeration unit, and use of a high-pressure fireproof-fluid hydraulic system and a digital electrohydraulic regulating system.

## II. General Survey of the 300-MW Nuclear Power Plant Steam Turbine Unit

### A. Thermal Power System

This unit contains a 7-stage regenerative heating system: three high-pressure heating stages, one deaeration and heating stage, and three low-pressure heating stages.

In the high-pressure heating unit, the steam source is bleed steam from the high-pressure turbine stage, while the steam source for the deaeration removal unit and low-pressure heating unit is bleed steam from the low-pressure turbine stage.

The heating steam for the first-stage reheat unit is the first-stage bleed steam from the high-pressure turbine unit, and the drain water is fed to the No 2 high-pressure heating unit; the heating steam for the second-stage reheat unit is fresh steam from the main steam valve, and the drain water is fed to the No 1 high-pressure heating unit; the drain water from the moisture separator is fed to the deaeration removal unit.

The guaranteed heat consumption in rated operation with the regenerative system functioning normally is 10,760 kJ/kWh.

### B. Basic Structure

The two main steam pipes from the primary-circuit steam generator are connected to the intakes of the two main steam valves, located on either side of the high-pressure unit; each of the main steam valves, in combination with two regulating valves, forms the intake valve unit, with a Y configuration. The steam intake valve and its flexible support plate are anchored to the foundation by a common base. The regulating valve outlet is joined to the high pressure unit by four flexible pipes, and the steam enters the steam vessel from the upper and lower halves of the central section of the high-pressure unit. The four steam exhaust openings are located at the two ends of the upper half of the high-pressure unit; they are ultimately joined as two steam pipes that run to two separator-reheaters located on either side of the turbine platform. After moisture removal and reheating, the steam passes into the upper sections of the two low-pressure units from the two sides of the platform via four pipelines. The exhaust steam of the low-pressure units directly enters the condensors located on the lower section of the turbine platform. The low-pressure unit is joined to the condensor by flexible connectors.

The unit consists of three casings and four steam exhausts and a single-shaft arrangement. The one dual-flow high-pressure turbine unit and two dual-flow low-pressure turbine units are arranged in series in the axial direction; the rotors are each supported by two radial bearings, with a long shaft between the two low-pressure rotors. Rigid shaft couplings are used between rotors and also between the rotors and the shaft, and a rigid connection is used between the low-pressure rotor and the generator rotor, thus forming the shaft series.

### C. The Regulating System

The intrinsic characteristics of nuclear power plant saturated-steam turbines (low temperature and pressure, high mass flow, large size of the steam vessels, separator-reheater unit, piping and valve assemblies) imposed the following special requirements on the regulating system.

1. The thermal power of the reactor is varied in response to changes in turbine power. This requires that the steam turbine be able to emit a power change signal in order to regulate the thermal power of the reactor, thus allowing it to adapt to changes in external load.

2. When the main steam valve of the turbine is shut, the pressure regulator opens the exhaust valve and vents the steam directly to the condensors in order to prevent a pressure rise in the primary circuit. When the turbine is being started up, the exhaust valve can be used to adjust the steam pressure in the primary circuit.

3. When the load is removed from the unit, the regulating system must be able to decrease the dynamic overspeeding of the unit rapidly and sensitively.

4. If a malfunction in the electric power system trips the generator, the unit must be able to maintain operation at 5 percent power for in-house use.

To meet the above requirements, a high-pressure digital electrohydraulic (DEH) system using fireproof fluid is used. It has the following features.

1. In normal operation of the unit, the reactor power follows the turbine load. In case of a reactor malfunction, the turbine regulating system can receive a load limitation signal from the reactor protection system and automatically limit the load or shut down.

2. The unit can start up or shut down at a preset rotation speed or rate of increase of rotation speed.

3. It can increase load at a preset power figure or rate of load increase.

4. The power load balancing system can rapidly close the high- or low- pressure regulating valves when the load is removed in order to prevent excessive overspeeding.

5. First-stage pressure feedback is used to correct for the flow-rate nonlinearity factor.

6. A load limitation feature is provided.

A block diagram of the high-pressure fireproof-fluid DEH regulation system is shown in the figure.

**D. The Moisture Separator-Reheater Unit**

This unit, of horizontal design, has one moisture separation stage and two reheat stages. The wet steam vented from the high-pressure unit enters the casing at the lower part of its high end section and the reheat steam enters the pipe bundle of the reheater from the upper parts of both ends. The circulating steam that has passed through the separator and reheater has become superheated. The steam passes from two outlets in the upper part of the casing to the two low-pressure units.

**III. Design Characteristics of the 300-MW Nuclear Power Plant Steam Turbine**

**A. Addition of the Separator-Reheater**

In light-water reactor power stations, the steam generator produces saturated steam (humidity less than 0.25 percent) at a pressure of 5-7 MPa; when this wet steam expands to condensation pressure in the turbine, unless appropriate steps are taken the final exhaust humidity will exceed 25 percent, which will greatly decrease turbine efficiency and will cause serious water corrosion of the turbine components, possibly even preventing normal operation.

As a result, a moisture separator-reheater unit must be installed between the high- and low-pressure units of nuclear power plant steam turbines. This unit separates water from steam containing 10-13 percent moisture that is exhausted from the high-pressure vessel, bringing it close to saturation, after which the steam is reheated (using fresh steam or bleed steam) producing a superheat of 70-80° C. In this way, the moisture content of the steam that is exhausted after passage through the low-pressure vessel can be kept at about 11 percent, close to the value for similar units in fossil-fired stations.

Use of the reheat cycle raises the ultimate thermal efficiency of nuclear power plant steam turbine units by the following amounts (compared with the non-reheat cycle):

| | |
|---|---|
| single-stage reheat | +(1.5-2.0 percent) |
| two-stage reheat | +(1.8-2.5 percent). |

Thus, use of the separator-reheater has the following distinct advantages.

1. Moisture can be separated from the steam flow in order to increase turbine safety and extend the operating life of its components.

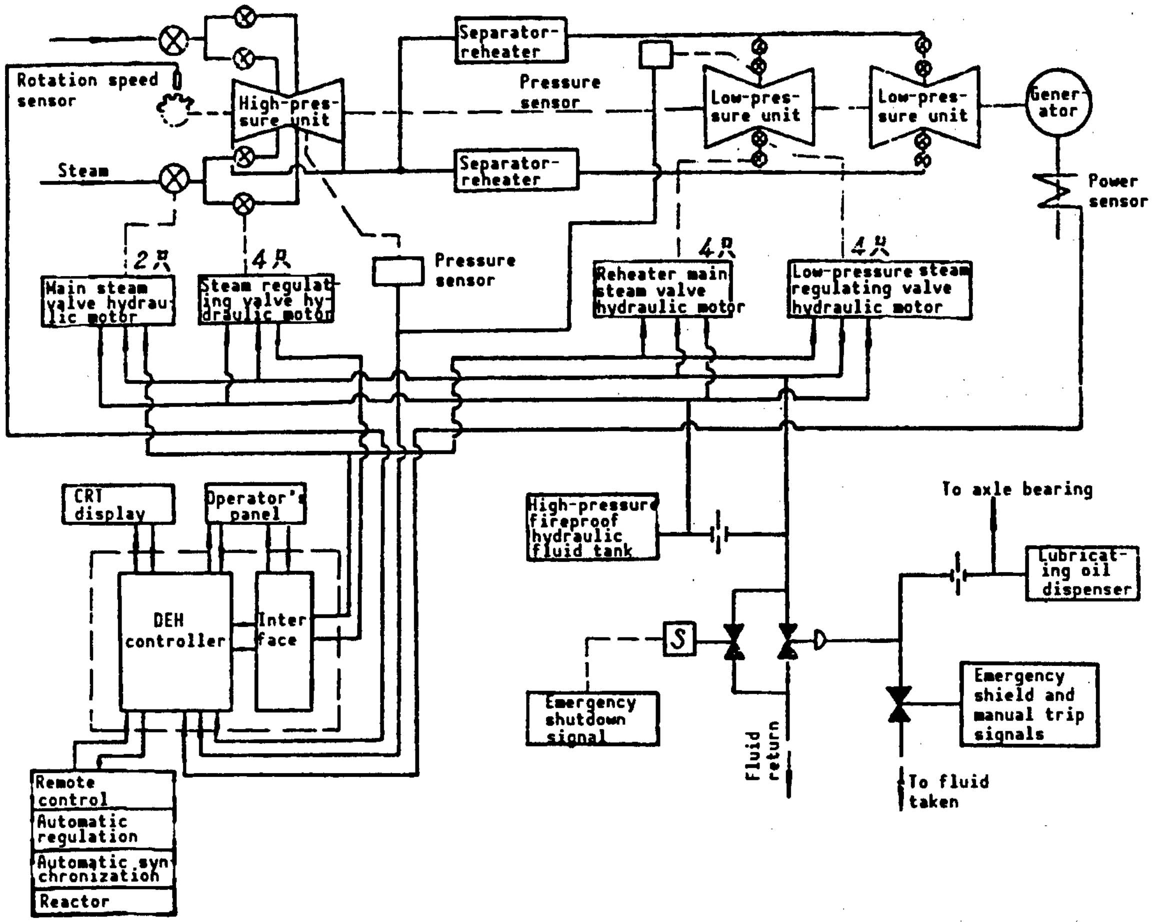
2. Use of fresh steam and bleed steam to heat the circulating steam makes turbine operation more economical.

**B. Use of a Two-Level High-Pressure Vessel**

Although the intake steam temperature in nuclear power plant steam turbines is much lower than in fossil-fired plants, because of the special operating conditions of nuclear power plants, the thermal stress problems in the high-pressure vessel still must be handled with great care.

First, when the load changes rapidly, there will be a large corresponding change in steam temperature. In addition, in a hot startup, when the transition is mad from the superheated state produced by flow regulation to the saturated state, the evaporation of moisture from the surfaces of the turbine parts produces abrupt cooling, which may result in a negative temperature difference, causing in stress and deformation.

When the load is removed from the steam turbine, the sharp drop in steam pressure within the high-pressure unit causes flash evaporation of the moisture film on the surfaces of the casing and stator components; the latent heat for this evaporation is entirely supplied by the metal in contact with the water film, with the result that the temperature of the vessel surface drops rapidly, producing very large temperature gradients between the surface and interior of the materials, and thus very large thermal stresses.




Using a high-pressure unit of two-layered design decreases such temperature differences, which is an effective way of decreasing thermal stresses and the resulting deformation.

### C. Moisture Removal and Anticorrosion Measures in the High-Pressure Vessel

The entire high-pressure unit of the nuclear steam turbine operates in the wet-steam mode and the humidity of the exhaust steam can reach 12.4 percent. Owing to the high density and pressure of the steam, the moisture in it forms a uniform fog, which moves with the steam flow, so that relatively few water droplets move toward the outer edge, and far fewer water droplets concentrate near the contour of the meridional plant than in the low-pressure vessel. As a result, moisture removal is somewhat more difficult in the high-pressure unit and the water removal rate is smaller.

The following water removal measures are usually used in high-pressure units.

1. Water removal through bleed holes.

2. Provision of tangential drainage holes in the bottom of the lower half of the stator blade retaining ring, where the moisture content is highest, to remove accumulated water from the blade tips in the region of high moisture content.

Erosion of components in contact with high-speed wet steam is one of the major problems of nuclear power plant steam turbines. Erosion develops primarily at the contact surfaces of such stationary parts as the steam vessel, the retaining rings and steam seals, and on supporting surfaces. The following steps were therefore taken.

1. The inner and outer high-pressure casings and retaining rings were made of cast chromium-molybdenum steel.

2. The supporting surfaces between the retaining rings and the steam vessel, between the steam seals and the outer casing, and between the inner and outer casings were built up with facings of chromium stainless steel.

3. The steam seal grooves of the retaining rings were faced with chromium stainless steel.

4. The separation surfaces between retaining rings were built up with Inconel alloy.

5. The steam seal bodies and rings were made of 12-percent chromium steel.

**D. Moisture Removal and Erosion Protection in the Low-Pressure Vessels**

Owing to the low steam pressure and large water droplet size in the low-pressure unit, corrosion and water erosion occur primarily on the rotating parts, particularly rotor blades. The following measures were therefore taken.

1. Steam-bleed moisture removal was used. Each of the last four stages operating in the west-steam zone was provided with steam bleed openings so that the water droplets in the steam would be drawn out together with the bleed steam.

2. Steam removal fingers and water grooves placed on the baffles of the last and next-to-last stages were effective in removing water droplets that accumulated on the outer edges of the blades.

3. The axial spacing between the rotor and stator blade in the last stage was increased to make the droplets finer and accelerate them, thus decreasing their erosion of the blades.

4. The back arcs of the steam-entry sides of the rotor blades in the last and next-to-last stages were hard-faced with stellite alloy to increase their resistance to water erosion.

5. The static steam grooves on the outer edges of the fourth- and fifth-stage rotor blades were built up with chromium stainless steel.

**E. Prevention of Excessive Overspeeding in Turbine Shutdown**

The volumes of the low-pressure elements must be far greater in the saturated-steam turbines of nuclear power plants than in the steam turbines of fossil-fired power plants of the same capacity. This fact, together with the large size of the separator-reheater unit and the connecting tubes, results in a very large steam flow space.

Under normal operating conditions, the surfaces of the flow passage of saturated-steam turbines and the surfaces of the vessels and tubing are covered by a water film, generally a few tens of microns thick, and in some places several hundred microns thick, and in addition, standing water accumulates in some locations; if the load is removed from the turbine and the steam pressure drops, the water film may evaporate into steam, which will function within the turbine and will increase the possibility of overspeeding.

In addition, the separator-reheater unit and the connective piping have large volumes and contain large amounts of steam and water, which is an important factor in producing overspeeding. Calculations indicate that these factors account for 70-80 percent of total overspeeding.

Table 1 shows the volumes of steam and water in the various turbine elements.

**Table 1. Steam and Water Volumes of Elements of Nuclear Power Plant Steam Turbine**

| | High pressure unit intake piping | High pressure unit | Piping from high pressure unit to separator-reheater | Separator -reheater | Piping from separator -reheater to low pressure unit | Low pressure unit |
|---|---|---|---|---|---|---|
| Steam ($m^3$) | 7.51 | 6.51 | 58.25 | 240 | 58 | 15.96 |
| Water (kg) | 70.65 | 82.62 | 199 | 2000 | — | 153.08 |

It will be seen that when the load is removed from the turbine, these large volumes of steam and water are converted to additional energy, which increases the overspeeding. If special steps are not taken, the maximum overspeeding may reach 25-30 percent, which is clearly unacceptable.

Foreign design and operating experience indicates that installing two fast-closing valves upstream of the intake to the low-pressure unit is an effective way of preventing overspeeding.

Analysis and computation of overspeeding characteristics gave the results shown in Table 2.

**Table 2. Effect of Value Arrangement and Characteristics on Overspeeding**

| Value arrangement | Value delay time, seconds | Value closing time, seconds | Maximum overspeeding, percent | Time to reach maximum overspeeding, seconds |
|---|---|---|---|---|
| No value upstream of low pressure cylinder | 0.2 | 0.5 | 12.94 | 17.60 |
| Value upstream of low pressure cylinder, no leakage | 0.2 | 0.5 | 3.33 | 1.22 |
| Value upstream of low pressure cylinder, 8 percent leakage | | 0.7 | 3.90 | 1.65 |
| | 0.2 | 0.5 | 3.45 | 1.60 |
| | | 0.3 | 2.90 | 1.48 |

The calculations indicate that with a valve delay time of 0.2 seconds and a closing time of 0.5 seconds, the degree of overspeeding is only 3.45 percent, so that there is no problem of excessive overspeeding.

**F. Comprehensive Intake Steam Flow Regulation and Distribution**

Since the nuclear power plant steam turbine is intended to carry up the base load, it must have rather high efficiency. In the flow regulation method, under rated operating conditions the valves are all open in order to decrease flow regulation losses, thus giving good economy.

Because the steam intake mass flow is rather large in saturated-steam turbines and the first-stage rotor blades are rather long, it is difficult to keep the bending stress on them low. When the first regulating valve is opened, the bending stress will reach its maximum, and since, moreover, the steam flow velocity in the regulation stage generally exceeds the critical value, at large steam flow densities unstable steam condensation can produce very large dynamic stresses. In addition, the form of the steam chambers may also result in extreme local nonuniformity of moisture content upstream of the stage, producing high local moisture concentrations, and the resulting water flows may damage the nozzle openings and produce additional pulses against the rotor blades, possibly causing fatigue damage.

As a result, many saturated-steam turbines for nuclear power plants use the comprehensive steam intake regulation method in order to increase safety.

To summarize, nuclear power plant steam turbines are distinctly different in several respects from those of fossil-fired plants, and as a result, special consideration must be given to design, system selection, strength calculations and safety in order to assure that the quality of the unit meets the requirements of the entire power plant project.

## Solar Energy Development Strategy for Eighth FYP Discussed

*40130067a Beijing KEJI RIBAO in Chinese 10 Jan 89 p 2*

[Article: "China's Solar Power Development Strategy for the Eighth 5-Year Plan Discussed"]

[Text] The China Solar Energy Society recently held a directors' meeting in Guanzhou at which 35 experts and scholars from all over the country discussed solar energy development strategy for the Eighth 5-Year Plan.

In recent years China has been making great strides in the utilization of solar energy. A million square meters of solar water heaters are in use nationwide, the total area of solar buildings has reached 170,000 square meters, more than 100,000 solar ovens are in use, 100 solar driers have been built, and the total area of solar collectors has reached 10,000 square meters. A rather advanced scientific and technical contingent for solar energy research has taken shaape. A set of valuable research results has appeared, and some are near or at the world state of the art.

But the conference participants also noted that there are still many problems in solar energy utilization, and that the leaders of some departments and units do not attach sufficient importance to it, there is a severe shortage of research funds, the ranks of scientific and technical personnel in the field are shrinking, and the new generation of researchers has not yet filled the gap. There is a lack of suitable management and quality control organizations for the solar industry, and some solar energy devices are crudely made, which is damaging the reputation of solar products.

In view of the above circumstances, the experts concluded that increased awareness of the great importance of solar energy utilization is the key to effective solar energy utilization during the Eighth 5-Year Plan and that a long-term strategic view should be taken.

During the Eighth 5-Year Plan applications should be treated as the breakthrough area, and influential demonstration projects should be carried out in order to stimulate the formation and maturation of China's solar products industry. The state should draft appropriate policies and guidelines for new energy sources, accord special treatment to applications in this field, establish patronage-style management of certain products, strengthen quality oversight, and make effective efforts at standardization. The experts concluded that under China's specific circumstances, during the Eighth 5-Year Plan China's output should expand steadily, and should be about a million square meters of solar buildings, 5,000 to 10,000 solar ovens, about 300,000 square meters of solar water heaters, and 2-3 MW of solar batteries each year. The experts also concluded that the strengthening of basic research on solar energy should be continued. Thorough investigations should be conducted in such fields as photothermal conversion, photochemical conversion, storage and biomass conversion, and windmill aerodynamics, obtaining results on a par with the world state of the art. Advanced research personnel should be trained so that the research contingent in solar energy will continue to be of adequate size and will become increasingly vigorous.

## Conference Focuses on Prospects for Geothermal Energy

*40130063b Shanghai DONGLI GONGCHENG [POWER ENGINEERING] in Chinese No 6, 15 Dec 88 p 64*

[Article: "Geothermal Power Generation Technology Conference Held in Qingdao"]

[Text] The Geothermal Electric Power Technology Conference, held jointly by the Power Engineering Institute of the China Mechanical Engineering Society, the China Electrical Engineering Technology Society, the China Electromechanical Engineering Society, the Xizang Geothermal Development Company and the Qingdao Steam Turbine Plant, took place at Qingdao on 7 October 1988. This inter-system, inter-science activity was well received by representatives from scientific and design departments, advanced schools, geothermal power plants, manufacturing plants, cognizant enterprises and administrative departments. A volume of 21 papers from the conference has been published. The central topics were: design, development and operating experience with equipment at the Yangbajing Geothermal Power Plant in Xizang; experiments and technical problems related to geothermal wells; and future development prospects. In addition, the state of development of medium- and low-temperature geothermal power generating equipment and two-working-medium circulation units abroad was described. Recently, geothermal waters with temperatures above 200° C were struck in the Yangbajing and Yangyixiang areas, and it is estimated that the power generating capacity per well may reach 5000 kW. The conference discussed the great importance of these deep-lying geothermal resources for the development of geothermal power generation in Xizang and suggested that while perfecting existing 3000-kW generating units, early efforts should be made to develop modular generating units with adaptable characteristics and with capacities of 6,000 to 12,000 kW, which will require a high degree of automation and the use of microprocessor monitoring and control. This not only would satisfy the development requirements of geothermal power generation in Xizang, but would also help get Chinese products onto international markets. In addition, in order to make more effective use of the high-volume, wide-area medium- and low-power geothermal sources, we should begin by importing mature foreign 1000-kW two-working-medium circulating units and in addition proceed with certain types of new technologies in order to promote China's progress in geothermal power generation technology.

## Conservation Seen Critical To Long-Range Energy Planning

*40130053 Beijing GUANGMING RIBAO in Chinese 16 Dec 88 p 1*

[Article by Zhao Mingliang [6392 2494 0081] and Liu Sa [0491 7366]]

[Text] By the year 2000 China wants its gross value of industrial output to be quadrupled, but energy production can only be doubled. How will this be possible? Energy experts believe that the answer lies in conservation.

Chief engineers in coal, electric power, and petroleum met with the press on 15 December and said that China's energy production has been increasing year after year but there is still a strong shortage of energy. Today, electric power is in short supply in the whole country, including the northwestern region and Guizhou Province where such shortages are unprecedented. The shortage of coal is also being felt throughout the national economy.

Experts believe that the energy shortage will get worse and do not expect any relief in the short term. Since the energy supply must come from within China and cannot rely on imports, conservation is becoming critically important.

Experts pointed out that there is enormous waste in China's energy usage. This is reflected mainly in the low rate of energy utilization, which places China among the lowest in the world. Conservation has always been our slogan, but over the decades the energy consumption per 10,000 yuan of production value has not been going down noticeably; this is an important reason for China's energy shortage.

The experts suggested that, in the reduction of fixed asset investments, high energy consumption investments must be reduced the most. Development of energy-intensive enterprises should be limited by adjusting the industrial structure. Out of the 10 billion yuan technology improvement fund of the nation, 15 to 20 percent should be devoted to technological improvements in conservation. Conservation laws and regulations should be established to strengthen the monitoring and control process, promote energy conservation in existing industries, and make enterprise leaders put a priority on conservation.

It is reported that the Ministry of Energy has formulated specific energy conservation measures and is prepared to launch a major development in heat and power cogeneration and medium-scale hydroelectric power stations. This would increase the supply of electric power without consuming more coal.

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